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SOVIET SOIL SCIENCE

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OF POCHVOVEDENIYE

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ROLE OF THE WARM HUMID SEASON IN SOIL FORMATION

V. R. VOLOBUYEV, Soil and Agrochemical Institute, Academy of Sciences, Azerbaydzhan, SSR

One of the most useful methods in studying seasonal aspects or phases of soil formation is that of stationary research in soil dynamics. Other methods should be employed in conjunction with it, however, especially the comparative geographic method. The previously established common zonal soil-climate laws are also of value. A comparison of soil maps with climatic maps of the warm and humid zones, compiled on the basis of the hydrothermal system (2, 3), may also be made. This system which is both climatic and pedological, shows the qualitative boundaries of the heat and moisture distribution. By using the hydrothermal graph and the corresponding data (annual precipitation, mean annual temperature, or annual radiation balance of the earth's surface), climatic maps of these zones may be compiled. Since the hydrothermal system is founded considerably upon generalization, the warm and humid zones compiled by means of that system correspond to a certain "average" annual cycle of climatic conditions. These zones will correspond very closely with soil geography in places of "normal" relationship between soil and climate.

As a methodic procedure, it is interesting to show the discrepancies between the warm and humid zones determined by the hydrothermal graph and soil geography as actually observed. Such divergencies indicate certain local peculiarities in soil formation which may be caused by historical and ecological factors.

In such investigations it is useful to construct special graphs showing important phases of the soil's hydrothermal system in soil formation. In literature there are several suggestions for constructing annual hydrothermal graphs (4, 7, 8, 11, and others).

The hydrothermal graphs shown in Figure 1 have been useful in studying soil-climatic relationships in the annual cycle. These graphs are generalized and have been compiled from the average observational data of all meteorological stations located in warm and humid zones or those of other types of soil distribution.

An attempt is also made to explain the significance of certain seasonal peculiarities in soil formation by the comparative geographic method. This type of research may be regarded as soil-ecological. It is obvious, however, that this does not provide complete characterization of the seasonal cycle in soil formation, which, in the final analysis, should reveal the course of biological, physicochemical, chemical, and physical processes.

Podzols, sod-podzols, brown forest soils, and krasnozems of the subtropics were studied. Soils of this group are well known; all are formed by the participation of forest vegetation under moist climatic conditions, and present a consecutive series in accordance with thermal zonality on the earth's surface.

Let us examine the seasonal phases in soil formation in the podzolic soil group, using podzolic and sod-podzolic soils of the European part of the USSR and of North America. These soils are widely distributed within these territories and there is sufficient climatic data on them (Fig. 1). Let us also examine the data on the meteorological stations (there are comparatively few) concerning podzolic and sod-podzolic soils of the Far East and sod-podzolic soils of Western and Central Siberia (Fig. 2).

The first general conclusion regarding podzolic and sod-podzolic soils in relation to values of the mean annual temperature and annual precipitation indicates that in all cases considered, a common soil-climate zonality is established: the existence of these soils according to a hydrothermal system under conditions E-FG, III-IV.[1]

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[1] Letters indicate the humidity series of the hydrothermal system: from A - extremely arid, to G - very humid. Roman numerals indicate the thermal series of this system: from I - extremely cold, to VII - equatorial-tropical (2, 3).

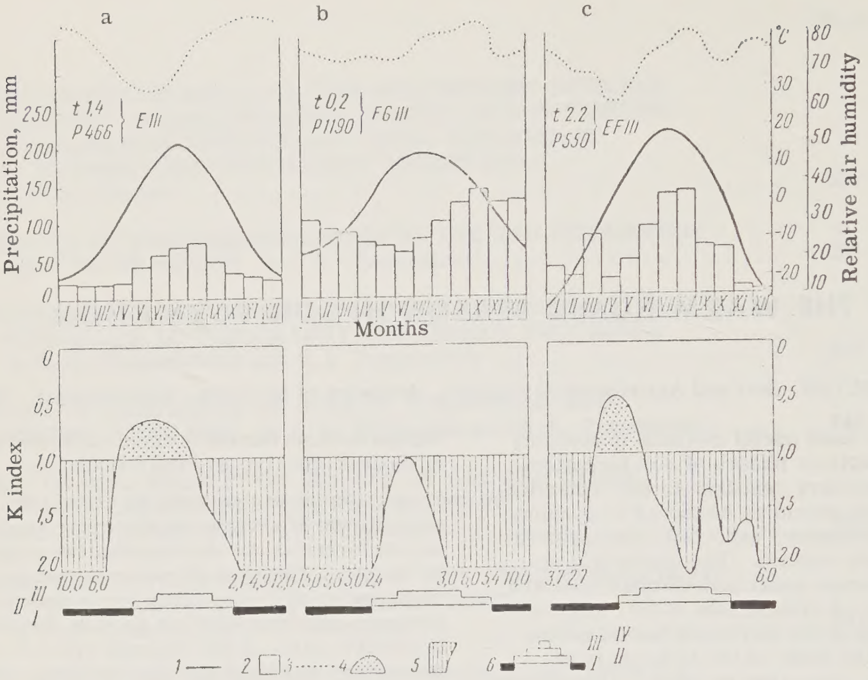

Fig. 1. - Hydrothermal conditions in regions of podzolic soils.

a - Podzols of the European parts of the USSR and Western Siberia (average for four stations). b - Podzols and sod-podzols of the Far East (average for three stations). c - Podzols of the USA (average for twenty-five stations).

Symbols: 1. Atmospheric temperature, (t)°C. 2. Monthly precipitation (P), mm. 3. Relative air humidity, %. 4. Periods with index $K_M = \frac{\text{precipitation}}{\text{evaporation}}$ 1, 5. Periods of $K_M > 1$ (K values > 2, shown by figures at bottom of graph). 6. Relative temperature levels of soil formation (I - less than 0°C, II - from 0 to 10°C, III - from 10 to 20°C, IV - above 20°C).

Several common differences should be pointed out between podzolic and sod-podzolic soils. Most podzols belong to Zone III, i. e. to a moderately cold zone, whereas the sod-podzols are primarily adapted to Zone IV, a temperate zone. The cycle of meteorological elements is unevenly distributed, the temperature curves are irregular, the relative air humidity and especially the cycle

$$K = \frac{\text{precipitation}}{\text{evaporation}}$$

vary substantially. There is, consequently, a basis for definite provincial peculiarities in conditions of soil formation. Beside great variations in the annual cycle of the individual climatic elements, certain common seasonal features are also observed. The first of these may be noted in the temperature level graph where we find the temperature to be uniform. There is a prolonged period of very low temperatures everywhere, and only two levels are characteristic for the period with temperatures above 0°C — 0 to 10°C and 10 to 20°C. Let us examine these levels in relationship to K.

The period of negative temperatures (level I) is coordinated with the periods having a large K. The low temperature period is the season of snow accumulation. This assumption is confirmed somewhat in the snow cover charts (10). In the zones of podzol and sod-podzol distribution in the USSR the duration of the snow cover is practically the same as the duration of the low temperature period in the figures (Figs. 1, 2). The low temperature period with high values of K may be called the frozen sub-snow phase of soil formation. Certain peculiarities in the condition of soil under snow were previously observed (5, 10, and others). Water entry cannot take place in frozen soil, and thus with the arrival of the warm period the soil will be moistened directly by atmospheric precipitation, and by moisture formed by the snow thaw accumulated during the low temperature period. The beginning of the warm period of soil formation is a period of leaching. This probably not only causes intensive leaching of the soil, but intensifies the anaerobic condition which began in the sub-snow phase. Especially conducive

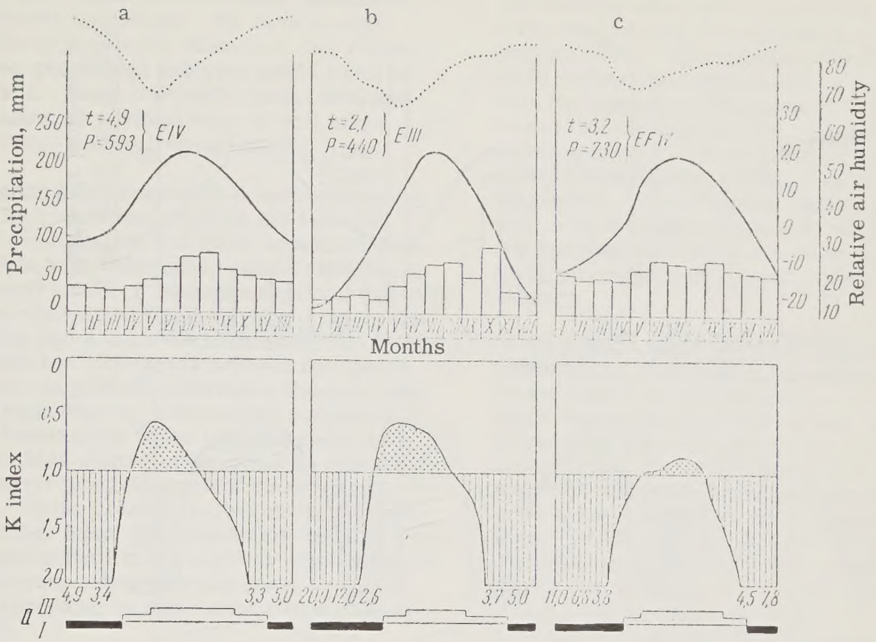

Fig. 2. - Hydrothermal conditions in regions of sod-podzolic soils.

a - sod-podzols of the European parts of the USSR, (average for ten stations). b - Sod-podzols of Western Siberia (average for five stations). c - Sod-podzols of the USA (average for 28 stations).

See Figure 1 for the meaning of symbols.

the latter are the early spring hydrothermal
nditions. This hypothesis is based on cir-
mstantial data, of course, but it should be
called that this combination of leaching and
cessively wet soil is a most important factor
the formation of podzols (12, 13).

Compared with the podzols, the sod-podzols
ve a longer warm period with a temperature
ove 0°C. The period with a temperature
ove 10°C is also longer than in the podzol
nes. From this it may be concluded that a
ger warm period with a temperature of 0-
C is favorable for the development of the
l elements of soil formation in soils of a
en group. Only the sod-podzols of Siberia
fer in this respect, having a warm period
h a temperature above 10°C which is shorter
n in the other two cases (Fig. 2). For zones
h a distribution of these soils, however, the
atest expression of the period with compara-
ely low humidity is characteristic. The
er is also obviously conducive to the sod
cess. Several other phases of soil forma-
n may also be mentioned, e. g. the quite
nmon decrease of the moisture phase in the
l during the first half of summer, shown by
cycle of K and the relative air humidity
g. 1. a, c and Fig. 2. a, b, c). During the second half of summer increased leaching conditions are created and these last until the fall-winter period. The moistening system of podzols in the Far East is peculiar; characteristic of these soils is an unusually great moistening during the second half of summer.

Thus, judging by the annual cycle of climatic elements in the regions of podzol and sod-podzol, the following seasonal phases of soil formation may be considered probable: a) a winter, frozen, sub-snow phase, b) a spring leaching phase with considerable excessive wetting, c) a summer phase with relatively low soil moisture, d) a fall leaching phase, and e) in various provinces a summer phase of great wetting.

Let us examine another group of forest soil which is subject to leaching: the brown forest soils. Their regions occur in Western Europe, the Far East, and the USA.

From Figure 3 it is evident that brown forest soils in all regions develop under typical climatic conditions. The average annual temperatures and the annual precipitation total indicate the formation of brown forest soils under cli-

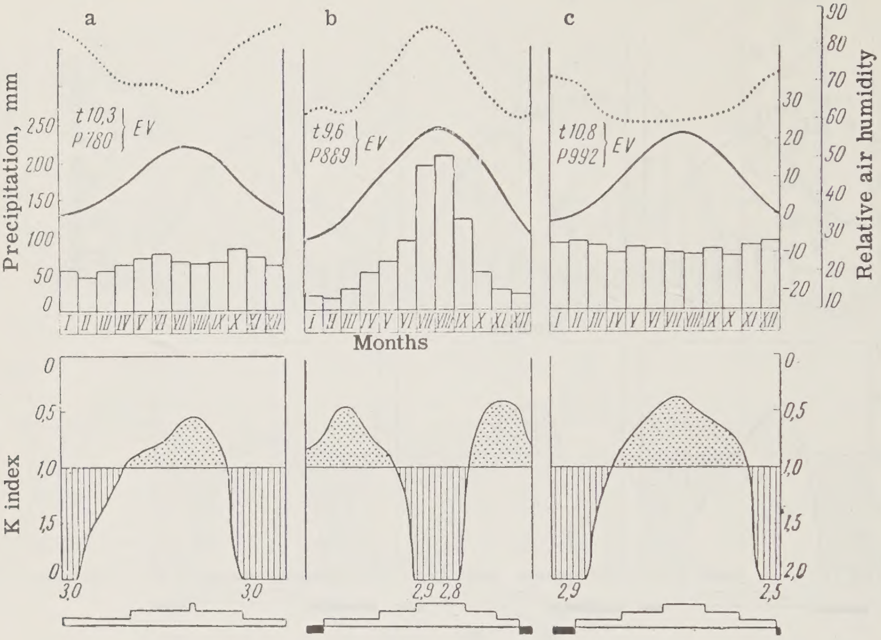

Fig. 3. - Hydrothermal conditions in regions of brown forest soils.

a - Brown forest soils of Western and Eastern Europe (average for 15 stations). b - Brown forest soils of the Far East (average for four stations). c - Brown forest soils of the USA (average for 33 stations).

See Figure 1 for the meaning of symbols.

matic conditions which are related to EV type in the hydrothermal system. It should be noted that the brown forest soils of the Far East are adapted to a climate with a lower mean annual temperature than in the other two regions.

At first glance the data of the annual cycle of climatic factors indicate great variations; this agrees with the tendency to interpret them as basically unlike. Actually, however, it must be assumed that in all observed instances there are monotypic phases in soil formation which also stipulate the formation of the characteristic features of the brown forest soils. Let us attempt to clarify this with a step-by-step analysis of the annual hydrothermal system.

First, we will examine temperature conditions. The winter phase of soil formation is not monotypic for these soils. The brown forest soils of the USA and the Far East are formed under freezing winter conditions, whereas those of Western Europe are usually formed without continuous freezing.

As a general soil formation condition for brown forest soils, a continuous active period of soil formation may be indicated by a mean monthly temperature of above 10°C, and a summer period with temperatures of 20°C and above. The latter is definitely expressed in the brown forest soil zones of the USA and the Far East, but may also be assumed for Western Europe as well, inasmuch as the mean monthly air temperature in June and August in this region is very near the 20°C limit. During the summer the soil temperature in Western Europe will evidently not be lower than in the brown forest soils of the USA and the Far East during the same period. The cooling factor of the stable winter frost period is absent here, also.

It would seem correct to associate the intensive processes of organic substance decomposition and the mineral transformation in brown forest soils with the continuous period of active temperatures (above 10°C), and especially with the summer phase of high soil moisture and increased temperature.

Beside these common seasonal phases which are characteristic for all brown forest soils of the Far East, we observe an absolutely specific phase: a sharply expressed leachin phase. The high humidity and leaching combined with the high temperature level of 20°C, may create conditions for an exceedingly inensive mineralization of organic substances nd mineral hydrolysis. We have no data vailable to prove this deduction, but a comarative-geographic analysis would seem to upport it. Some especially useful data are scertained by a comparison of soil maps nd thermo- and hydrozonal maps.

By comparing the thermal zones compiled n the hydrothermal graph on the basis of nnual precipitation and mean annual temperture data with the tundra, podzol, and brown orest soil zones, it becomes apparent that they re distributed relatively to each other in the uropean and Asiatic territories (2, 3). Thus, n Europe the boundaries between the tundra one and the podzolic (Northern Europe), and, a certain degree, between the podzolic and rown forest soils zones (Baltic areas) are nore or less shifted to the south as compared the corresponding thermal zones (II, III, V, V). In the coastal regions of the Far East, n the other hand, the boundaries between these ones are shifted to the north in relationship to heir corresponding thermal zones — estabshed according to mean annual temperature Fig. 4).

Let us examine this phenomenon more losely, using Eastern and Southeastern Asia s examples. By comparing the soil geography f leaching: krasnozems, zheltozems, brown orest soils, and podzols (Fig. 4. b) with the umidity zonal map (Fig. 4. a), it is evident hat distribution of these soils is closely reated to the zones of high humidity E, EF, F. here can be no complete coincidence of oundaries, owing to the complex nature of the elationship of the soil to the multifarious nedium and its development. Therefore we hall not attempt to clarify all instances of onformity or divergence in this paper. It nay be useful to point out the shift to the east f the brown forest soils in relationship to the one of high humidity (E) in the region of orth China. One wonders whether the derease in humidity during the monsoons is not n important factor.

The relationships between soil distribution nd thermal zones are of a different nature. rom a comparison of Figures 4 b and c, it ould seem clearly manifest that there is a hift of the soil zones to the north. Thus, the rown forest soils extend somewhat to the orth of Zone V: the zone of their normal disibution. The krasnozems appear to be wide- distributed in subtropic Zone VI, whereas sewhere (the Transcaucasus, USA, etc.) heltozems for the most part occur in this zone. Southeastern China, on the other hand, the heltozems in Zone II are found only in the inerior of the continent.

From these facts it might be assumed that this part of the Asian continent soil formation actually takes place at a higher thermal level than follows from the mean annual temperature data. The question naturally arises as to whether this peculiarity is connected with the monsoon hydrothermal system. It is known that the regions with monsoon climate are characterized by dry winters and humid summers; consequently, under monsoon conditions in summer, during highest temperatures, the soil is most highly moistened. That is, during the summer conditions are created for the most active cycle in the soil formation processes.

Even when mean annual temperatures are below typical distribution conditions for brown forest soils, the formation phase of these soils' characteristics takes place under temperature conditions that are normal for brown forest soils. In regions with a monsoon climate, however, where the mean annual temperature corresponds to the typical conditions for brown forest soil formation, the summer soil formation phase will take place with greater intensity than in the average for the zone. This may cause the appearance in the brown forest soils of characteristics peculiar to another soil type: the zheltozem.

All these differences in formation of the brown forest soils of the Far East should be regarded as provincial peculiarities, and they also explain the "zonal shift" of the brown forest soils in relation to their basic thermal zone — Zone V. It is also natural to assume a like "zonal shift" in relation to podzols.

Typical, then, for brown forest soils are the following seasonal phases: a) winter: frostless or slightly frosty humid phase, b) spring: warm, moderately humid phase, c) summer: moderately humid or humid phase with high temperatures (20°C and above) and d) fall: warm, moderately humid phase.

The high moistening of the soils of the Far East during summer causes a certain degree of water-logging rather than podzolization. This is a peculiarity of the brown soils in the Far Eastern province (9).

Evidently a broader interpretation may be given the established value of the warm, moderately humid phase in the formation of the brown forest soils. In this respect it would also be of interest to examine the zheltozem data.

To clarify the phases of zheltozem soil formation let us examine climatic conditions in the regions of zheltozem occurrence: the Eastern Transcaucasus, (Lenkoran zone), Western Georgia (Caucasus), and the southeastern section of the USA (Fig. 5). In these regions climatic conditions, as related to the hydrothermal system, correspond to type E

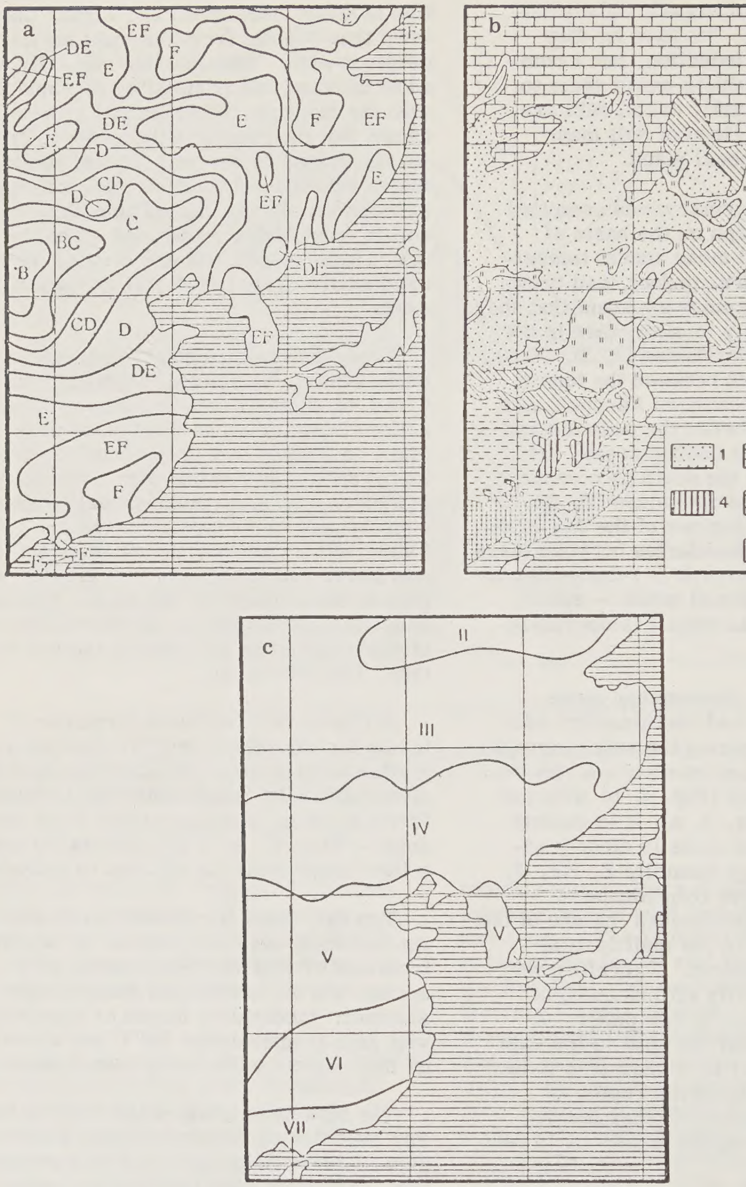

Fig. 4. - Climatic and soil conditions for parts of Southeastern Asia.

a - Climatic humid zones: B, BC - arid zone, C, CD - zone of insufficient moisture, D - zone of equalized moisture, DE - moderately moist zone, E, EF - humid zone, F - very humid zone. b - Generalized soil map. 1. moist soils without leaching: brown, chestnut, chernozem, cinnamon brown forest; 2. podzol and sod-podzol; 3. brown forest; 4. zheltozem; 5. krasnozem of the subtropics; 6. lateritic krasnozem, laterite; 7. meadow, bog, and saline soil of alluvial planes. c - Climatic thermal zone. II - cold zone, III - moderately cold zone, IV - temperate zone, V - moderately warm zone, VI - subtropic zone, VII - tropic zone.

VI, i. e. they are moist- subtropic.

With monotypic climatic conditions of primary characteristics, the seasonal cycle of the climatic factors in the zheltozem regions are exceedingly varied. As pointed out previously, however, in respect to podzols and brown forest soils, even when marked season variations exist, a proximity is established as regards the decisive phases of soil formation.

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The review made of seasonal variations in the hydrothermal system of several soil groups can explain the seasonal dynamics of soil formation only to a limited extent. The importance of the phases of the hydrothermal system to the cycles of biological processes of mineral transformation must be corroborated by direct factual data from stationary observations of soil dynamics, which, until now, have been very scarce. It seems to us that the test made of the comparative geographic analysis of hydrothermal systems of soils justifies several more positive deductions. When detailed and direct comparison of soil groups with climatic conditions was made, it was found that the formation of soil groups was associated with very definite types of moisture and thermal balance in soil formation. The formerly-suggested hydrothermal system (1, 2, 3) also indicates this connection. Especially confirmed was the adaptation of podzols, brown forest soils, and zheltozems to the hydro series E, EF, i. e. to the hydro series of the leaching hydral balance, with a gradual increase in the thermal balance (thermal series III, IV, V, VI).

Hydrothermal conditions of podzols and sod-podzols were recorded which should be interpreted as especially favorable to the rise of anaerobic conditions in combination with leaching (spring period). The conclusion was reached that the temperature level of about 20°C is the level at which the intensity of plant residue- and mineral transformation reactions in the soil begin to increase. The idea also has been expressed that a combined moderate soil moisture and increased temperature phase (above 20°C) is especially conducive to secondary mineral formation and formation of soils with an increased clay content in the soil mass. It may be assumed that these conditions especially favor the development of a reaction of mineral hydrolysis with plant residue substances.

It must be assumed that the similarity of difference between soil groups as related to hydrothermal conditions of soil formation are related to extreme differences in the annual heat and moisture balance or their basic seasonal variations. When hydrothermal conditions are essentially similar, even very great variations in their climatic cycle do not create changes in the soil which alter the nature of soil formation. Local hydrothermal peculiarities should usually be considered as accelerating or decelerating basic soil formation without, however, altering it basically.

It seems to us that in spite of the rather limited possibilities of the method employed in investigating the seasonal phases of soil formation on the basis of climatic data, similar work in all basic soil groups will produce useful data for the clarification of specific problems of soil formation under various climatic conditions.

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ORMS OF POTASSIUM IN THE SOIL AND POTASSIUM NUTRITION OF PLANTS[1]

G. VAZHENIN AND G. I. KARESEVA

The primary source of potassium nutrition f plants is exchangeable potassium. Most ontemporary chemical methods which charcterize soils in relation to potassium availbility are based on the determination of exhangeable potassium (Maslova, Peyve, Egnerim, Nering, Shakhtshabel', and others).

It has been proven, however, that very requently there is no relationship between e exchangeable potassium content in the soil nd the response of plants to potassium ferlizers. This is explained by two basic reaons: first, the response of plants to potasum fertilizer depends not only on the content f available potassium in the soil, but to a reat extent upon the properties of the plant self and the external conditions of its development: meteorological, agrotechnical, and thers. Second, it has been proven that plants se potassium not only in exchangeable form, ut in other forms as well.

Potassium in the soil may be expressed by e following forms:

1. Potassium in the soil solution.
2. Potassium in the soil adsorption complex.
   a) intensively exchangeable ions,
   b) extensively exchangeable ions,
   c) nonexchangeable ions.
3. Potassium in the soil particle (mineral fraction).
   a) extensively exchangeable ions,
   b) nonexchangeable ions.
4. Potassium in organic residue in the soil.

Potassium in the soil solution is active in ant nutrition, but does not create soil ferlity in proportion of this element. The innsively exchangeable ions are easily and pidly displaced from the adsorption complex neutral salt. This form of exchangeable potassium is considered basic and characterizes soil fertility in proportion to this element.

It has been verified by many experiments (4, 10, 14) that shortly after the displacement of potassium from the soil by neutral salt or weak acids, exchangeable potassium again appears in the soil in amounts which are often similar to the original ones. K. K. Gedroits showed this form of extensively exchangeable potassium to be available to plants.

Nonexchangeable ions are primarily of the crystal lattices of soil colloids and the skeletal fraction of the soil. If conditions are created which destroy, dissolve, or pulverize the lattice, nonexchangeable potassium will to a certain degree become exchangeable and available to plants.

According to present ideas, all forms of potassium in the soil participate in the potassium nutrition of plants, but in varying degrees.

Table 1 shows the potassium balance during the long-term experiment of the Solikamskaya Experimental Station in sandy sod-podzolic soil. This experiment with continuous potatoes for "forms of potassium fertilizer" was begun in 1933. Average yields of potatoes for 25 years were as follows: without fertilizer: 40-50 cntr/ha, without potassium (NP): 60-80 cntr/ha, with potassium (NPK): 100-200 cntr/ha.

It follows from Table 1 that in treatments without fertilizer and NP, the average yearly removal of potassium from the soil amounted to 21 and 28 kg/ha of K_2O respectively. The average yearly removal of potassium with NPK amounted to 30 kg/ha of K_2O, and with the most effective form of potassium fertilizer: potassium sulfate, the removal of potassium from the soil amounted to 80-100 kg/ha of K_2O during various years.

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Table 1

Potassium balance in long-term experiment with continuous potatoes
(Solikamskaya Experimental Station)

Fertilizers	Dry mass yield for 20 years, cntr/ha		K_2O balance, kg/ha		Average yearly removal from soil	Ex. potassium in 0-120 cm layer, kg/ha of K_2O[a]
	tubers	tops	applied	removed		
Without fertilizer	221	86	—	416	21	735
Withoug potassium	347	153	—	558	28	745
NP K_{60} (90)	731	323	1350	1956	30	723

[a] Exchangeable potassium content in virgin soil (in 0-120 cm: 896 kg/ha of K_2O.

Which forms of potassium were assimilated by plants? The last column in Table 1 shows the exchangeable potassium content in the soil in a layer of 0-120 cm. As we see, the amount of exchangeable potassium decreased by 150-170 kg/ha, while the removal of potassium from the soil amounted to 400-600 kg/ha of K_2O. Consequently, the potatoes assimilated not only exchangeable potassium, but extensively exchangeable potassium, and to a certain degree, nonexchangeable potassium, primarily from the smallest soil particles. This is proven by the fact that during the 15 years of the experiment in the NP and NPK plots, in which there was a greater removal of potassium by crops, its total content decreased in the particles of <0.001 mm diameter.

Fertilizer	% of particles <0.001 mm in diameter	% of K_2O in particles <0.001 mm in diameter
Without fertilizer	2.88	2.09
Without potassium (NP)	2.12	1.73
With potassium (NPK)	1.96	1.86

Table 2 shows the balance of potassium in another long-term experiment of the Solikamskaya Experimental Station — in sandy loam sod-podzolic soil. Three crops were rotated: potatoes, turnips, and wheat. Very high fertilizer saturation characterized the experiment: N_{90} P_{90} K_{120} were applied under the turnips, and N_{45} P_{45} K_{60} were applied under wheat.

These mineral fertilizers were applied without manure (20 metric tons/ha under potatoes and turnips) and lime (at the beginning of the experiment). Average yields for 15 years were as follows:

Potatoes — manure plus lime	180-200 cntr/ha
with NP and NPK	300-350 "
Turnips — manure plus lime	200-250 cntr/ha
with NP and NPK	400-450 "
Wheat — manure plus lime	12-12 "
with NP and NPK	20-25 "

In spite of the systematic application of manure and the heavy applications of potassium fertilizers, the average removal of potassium by plants was greater than the amounts applied to the soil. Potatoes were the heaviest consumer of soil potassium. During the 15-year experiment, the average removal of potassium by potatoes was 163 kg/ha greater than was applied in manure and mineral fertilizers. In individual years, when potato yields amounted to 300-350 cntr/ha, the removal of potassium from the soil was still greater. In the treatment without potassium (NP) the average yearly removal of potassium from the soil was as follows: for potatoes 230 kg/ha of K_2O, while the average for all three crops was nearly 100 kg/ha of K_2O, which is considerable for sandy loams.

Thus, liming, applications of manure and mineral fertilizers, and the high level of agricultural practices provided excellent plant development and were conducive to the mobilization of soil potassium by the plants.

The mobilization of potassium by plants took place largely from the nonexchangeable forms. In the treatment without potassium (manure + lime + NP) during the 15 years of the experiment, potassium was removed in the amount of nearly 1.5 metric tons/ha of K_2O

Table 2

Potassium balance in long-term field experiment on sod-podzolic sandy loam (Solikamskaya Experimental Station)

Fertilizers	For 15 years		Average yearly potassium balance				Exchangeable potassium in 0-50 cm layer[a]
	applied	removed	potatoes	turnips	wheat	average for 3 crops	
	potassium, kg/ha of K_2O						
Manure + lime	1000	1450	-95	+20	-16	-30	960
Manure + lime + NP	1000	2405	-230	-26	-25	-94	780
Manure + lime + NPK	2500	2945	-163	+49	+26	-29	1290

[a] Exchangeable potassium content in 0-50 cm layer in virgin soil (abandoned land) 870 kg/ha of K_2O.

from the soil, i. e. about twice the amount greater than the exchangeable potassium present in the half-meter soil layer. The content of exchangeable potassium in this soil layer decreased by less than 100 kg/ha of K_2O during the experiment. It is interesting to note that with manure plus lime, and especially with potassium fertilizer (manure + lime + NPK), an increase in exchangeable potassium in the soil was noted, although the potassium balance as a whole remained negative.

From these data it follows that as a source of nutrition the plants used exchangeable (intensively exchangeable), and extensively exchangeable potassium and its nonexchangeable forms.

The following pot experiment with oats (Table 3) and its results testify to the ability of plants to assimilate nonexchangeable forms of soil potassium. As a source of potassium, during the first series of the experiment, soil which had first been saturated with potassium at a rate of 0. 25 g exchangeable potassium per container was placed in one mixed with sand. In the second series the clay fraction (<0.001 mm in diameter) of the same soil was used which had first been saturated with calcium (to remove the exchangeable potassium) at a rate of 2. 5 g of K_2O per container.

On the basis of the oat yield it may be concluded that the availability of exchangeable potassium in the soil is in direct proportion to the adsorption capacity: it increases from sandy sod-podzolic soil to chernozem. In the same soil order the availability of nonexchangeable potassium increases (second series of the experiment). The great availability of potassium in sierozem is due to the fact that the clay fraction of sierozems contains a large amount of mica, an excellent source of potassium nutrition.

The function and value of micas and other potassium-bearing minerals in potassium plant nutrition are well known. More than 40 years ago D. N. Pryanishnikov proved the availability to plants of potassium in muscovite, biotite, nepheline, glauconite, and other minerals which had been ground to silt sizes. Slightly available was the potassium in feldspars and leucites, especially for such plants as millet and buckwheat (6, 7, 8). But if heavy applications of feldspar were made, plants satisfied their potassium requirements to a certain extent from this mineral also. In Tyner's experiment (15) feldspar was applied in containers (sand cultures) in proportions of 5 metric tons/ha. In this case alfalfa and clover developed well, corn, oats, and especially buckwheat developed less.

In Lewis and Eisenmenger's pot experiments (12) orthoclase applied in proportions of 310 kg/ha of K_2O increased the potassium content in plants by 75% (larkspur, rape, lespedeza, poppy, geranium) as compared with the blank test (sandy loam which had received no potassium fertilizer for 55 years).

In the sand and silt fraction of the majority of soils, feldspar content comprises 5%-10%; in the fine silt fraction it is still higher. The mica content is expressed as 5%-10%, while in sierozem and chestnut soils it is considerably greater (1, 5, 9).

In 1956-1958 we made a pot experiment to study the availability to plants of potassium in minerals applied in the form of various fractions. The particles <0. 001 mm in diameter were applied at a rate of 1 g per 1 kg of sand, the particles 0. 01-0. 1 mm in diameter at a 10-fold rate, and the particles 0. 1-0. 25 mm in diameter at a 25-fold rate, i. e. in amounts of 2. 5% of the weight of the sand. The minerals were applied once, at the beginning of the experiment (1956), and the soluble salts, in Helrigel's mixture, were applied annually. The potassium was a mixture

Table 3

Availability of soil potassium for oats in pot experiments (sand culture)

Soil	Potassium in soil		Oat yield[a]			
	Total in <0.001 mm diam. fraction	Exchangeable (content mg/eq)	I: NP + K Exchangeable		II: NP + K of <0.001 mm diameter fraction	
			g/cont.	% of NPK	g/cont.	% of NPK
Sierozem, Samarkand	2.87	25.6	20.8	86	18.7	78
Chernozem, Chelyabinsk	2.12	46.8	22.8	95	15.2	63
Darkgrey, Kungur	2.18	25.1	18.7	78	13.7	57
Sod-podzolic, fine clay loam, Perm.	2.31	21.3	16.6	69	12.5	52
Sod-podzolic sandy loam, Solikamsk	2.48	8.6	13.4	56	11.8	49

[a] Oat yield with normal nutritive mixture (NPK): 24.0 g/container; with 1/10 application of potassium: 9.1 g/container.

of 0.1 g of K_2O to 1 kg of sand (0.27 g per container). In 1956 corn was used as a test crop, in 1957 buckwheat, and in 1958, oats. The corn was harvested in the ear stage, the buckwheat and oats at the beginning of bloom.

In 1958, oats in the tillering stage displayed definite signs of potassium deficiency in all treatments, with the exception of the following: the normal nutritive mixture, biotite in the 0.01-0.1 mm diameter particles, and nepheline in the 0.01-0.1 mm diameter particles. To preserve the plants in the experiment, K_2SO_4 in 1/10 portions was applied in all containers with the exception of the normal nutritive mixture treatment and the treatment without potassium. The plants quickly recuperated and continued to develop quite normally. Table 4 gives the yields of the crops studied, their potassium content, and its removal by plants. Of the three crops buckwheat showed the least assimilating ability. For all crops the order of potassium assimilation was the same: biotite>muscovite>granite>nefeline>microcline.

In the experiment the effect of particle size of the mineral on the plant yield and assimilation of potassium was clearly evident. Potassium is assimilated from the clay fraction (<0.001 mm in diameter) of mica more readily than from the sand fraction (0.01-0.1 mm), but owing to the heavy application (10 times) of the latter, the total removal of potassium from it proved to be greater. With granite containing biotite, yields and removal of potassium increased in the same order.

Consequently, if the soil contains a large amount of mica, even in the sand fraction, plants may be considered to be sufficiently well supplied with potassium. We have observed a similar phenomenon in Buryat Mongolia where soils are frequently found which are formed on the eluvia and proluvia of granites; these soils are of very coarse texture, detrital, and gravelly. Potassium fertilizers had no effect on them in spite of the low content of exchangeable potassium.

With microcline, a mineral with very low solubility, the removal of potassium by corn and oats was on a level of 1/10 application of potassium in the Helrigel mixture. Such potassium removal must be recognized as unusually great. Consequently, even microcline, when its content is sufficiently great in the soil, may be a source of potassium. The total removal of potassium by the three successive crops is shown in Table 5. From the biotite clay fraction 70% of the potassium present was adsorbed by the plants, i. e. the removal was the same as under application of soluble salt with a 1/10 proportion of potassium. The availability of potassium in the sand fraction of biotite (0.01-0.1 mm in diameter) amounted to 28%, three times greater than in the same fraction of muscovite.

In the clay fraction of microcline the removal amounted to 28%, a very high value; in the sand fraction a negligible amount of potassium was removed. As is evident, in the case of the microcline the particle diameters (dispersion) play a more important role than is the case with mica. Proof of this is the experiment with buckwheat in containers to which minerals were applied after having been ground in a ball mill for 100 hours. The result was a sharp increase in the potassium availability in the microcline (by three times as compared

Table 4

Consumption of potassium bearing minerals as source of potassium (plant yields and their potassium content)

Potassium sources	Diameter of mineral fractions, mm	Corn (1956)					Buckwheat (1957)			Oats (1958)				
		Yield (g/cont.)		% K_2O in yield		removal of K_2O, mg/cont.	Yield, g/cont.	% K_2O in yield	removal of K_2O, mg/cont.	Yield (g/cont.)		% K_2O in yield		removal of K_2O, mg/cont.
		Tops	Roots	Tops	Roots					Tops	Roots	Tops	Roots	
Helrigel's mixture (comp.)	—	13,2	6,7	1,41	0,56	222	8,5	2,30	195	6,6	1,4	3,34	1,36	240
Same 1/10 potassium	—	4,2	2,2	0,40	0,42	26	3,0	0,59	18	2,8	1,1	1,02	0,40	32
Same, without potassium	—	—	—	—	—	—	0,5	0,39	—	0,7	0,5	0,44	0,20	4
Microcline	<0,001	4,8	2,4	0,38	0,56	31	1,2	0,58	7	2,8	0,8	1,20	0,30	36
"	0,01—0,1	4,4	2,2	0,42	0,55	30	0,8	0,67	5	2,3	0,7	1,39	0,31	34
"	0,1—0,25	3,9	2,0	0,34	0,52	23	0,6	0,69	4	2,3	0,8	1,28	0,32	31
Muscovite	<0,001	6,5	7,7	0,42	0,48	64	3,5	0,79	28	2,6	1,0	1,02	0,30	30
"	0,01—0,1	6,9	8,9	0,47	0,50	77	7,8	0,84	65	3,6	1,2	1,17	0,31	47
Biotite	<0,001	7,5	7,8	0,41	0,45	66	6,1	0,66	40	2,4	1,1	1,02	0,31	29
"	0,01—0,1	12,6	8,3	1,27	0,51	200	10,2	2,12	216	7,4	2,1	2,23	0,45	175
Granite	<0,001	5,3	4,2	0,42	0,49	49	2,3	0,54	12	2,8	0,7	1,02	0,31	31
"	0,01—0,1	6,5	6,3	0,45	0,51	61	3,1	0,55	17	2,8	1,0	1,13	0,31	35
"	0,1—0,25	7,3	6,9	0,39	0,50	63	4,2	0,58	24	2,8	1,1	1,23	0,33	38
Nepheline	<0,001	5,5	7,8	0,43	0,48	63	4,3	0,48	21	2,9	1,0	1,00	0,32	32
	0,01—0,1	5,7	5,6	0,46	0,49	55	3,7	0,50	18	4,9	1,2	1,42	0,36	75
	0,1—0,25	6,1	5,4	0,40	0,48	51	2,8	0,57	16	—	—	—	—	—

Note: Comma represents decimal point.

Table 5

Removal of potassium by plants from minerals used as source of potassium

Potassium sources	Potassium applied to container, mg/cont.	Total potassium removed by crops			
		K_2O mg/cont.			in % of amount applied
		Tops	Roots	Total	
Helrigel's mixture	810	596	61	657	81
Same 1/10 potassium	108	62	14	76	70
Microcline <0,001[a]	265	57	17	74	28
" 0,01—0,10	2567	54	15	69	3
" 0,10—0,25	6577	45	13	58	<1
Muscovite <0,001	220	81	41	122	56
" 0,01—0,10	2227	137	51	188	9
Biotite <0,001	192	85	50	135	70
0,01—0,1	2132	536	55	591	28
Granite <0,001	190	68	24	92	48
0,01—0,10	1587	77	36	113	7
0,10—0,25	3587	84	41	125	4
Nepheline <0,001	—	75	41	116	—
0,01—0,10	—	112	36	148	—
0,1—0,25	—	—	—	—	—

Note: Comma represents decimal point.

with the fraction <0.001 mm in diameter), and its effect on productivity and potassium removal approached muscovite.

What is the relationship of potassium availability to plants and mineral solubility? Table 6 gives the results of a potassium determination in various extracts (water, ammonium acetate and 10% HCl) in the fraction of minerals used in the vegetation experiment. The extracts were prepared with a ratio of 1:50 and hourly agitation.

Results of the analyses confirm: 1) that the solubility of micas, especially biotite, is considerably greater than that of other minerals, and 2) that the finer the particles the greater the solubility. The data in the table also show the unlike ratio of minerals to solvents, and point to the fact that the relationship between solubility and yields is not a simple and direct one.

The ratio of the micas (muscovite and biotite) to the solvents was shown to be very different: the water and saline extracts from muscovite removed several times more potassium than from biotite, while the solubility of muscovite in a 10% HCl extract was negligible: by tens and hundreds of times less than the solubility of biotite.

From a comparison of the solubility of minerals and plant yields (Table 4) it follows that: 1) the water extract does not show potassium availability in minerals (the same amount of potassium was removed from microline as from biotite and granite), 2) exchangeable potassium in minerals also shows no availability of their potassium to plants (from biotite, characterized by a very great removal of potassium by plants, as much potassium was removed by ammonium acetate as from microcline and granite, and several times less than from muscovite and even nepheline), and 3) the hydrochloric extract is better correlated with yields and removal of potassium by plants.

With an increase of the dispersion of minerals, their solubility and availability of potassium to plants increase. One wonders whether this is to be explained solely by an increase in the active surface and exposing new exchange surfaces, as set forth in the works of Kelly, Dore, and Brown (11). Investigations by Perkins, Dragsdorf et al. (13) show that in the ground minerals (kaolinite, bentonite, muscovite, metabentonite) the structure of their crystal lattice is destroyed, changing their properties considerably. These authors also show that as a result of grinding, the conversion into solutions of the minerals SiO_2, MgO, K_2O, and especially the sesquioxides, is increased. The same authors assume that in the mechanical grinding the bonds Si - O - Al are destroyed.

Gorbunov's and Sharina's investigations (3) have shown that in the mechanical pulverization of minerals in a dry state profound structural changes do take place. As the time of

Table 6

Solubility of potassium bearing minerals

Minerals	Diameter of fractions, mm	Total potassium content, %	Solvents			Total potassium removed	
			H_2O	CH_4COONH_4	10% HCl	mg	% of total
			mg K_2O/100 g.				
Microcline	0,25—0,10	9,71	<1	<1	5	7	0,1
	0,10—0,01	9,42	3	3	15	21	0,2
	0,01—0,001	9,00	7	14	44	65	0,7
	<0,001	8,82	41	151	218	410	5,0
	200 mesh	—	28	32	46	106	—
Muscovite	0,25—0,10	8,02	11	12	30	53	0,7
	0,10—0,01	8,17	15	22	80	117	1,4
	0,01—0,001	8,32	32	108	260	400	5,3
	<0,001	6,77	115	555	715	1385	20,2
	200 mesh	—	185	375	160	720	—
Biotite	0,25—0,10	7,53	2	2	2995	3000	40,0
	0,10—0,01	7,80	4	4	3842	3850	49,5
	0,01—0,001	8,22	8	15	5477	5500	67,0
	<0,001	6,11	56	197	5547	5800	94,4
	200 mesh	—	125	183	5190	5498	—
Granite	0,25—0,10	5,32	1	1	142	144	2,7
	0,10—0,01	5,82	3	4	168	175	3,0
	0,10—0,001	6,10	8	15	239	262	4,3
	<0,001	6,04	26	174	650	850	14,1
	200 mesh	—	17	19	209	245	—
Nepheline	0,25—0,10	—	2	17	—	—	—
	0,10—0,01	—	3	23	—	—	—
	0,01—0,001	—	5	45	—	—	—
	0,001	—	19	186	—	—	—
	200 mesh	—	7	55	—	—	—

Note: Comma represents decimal point.

ulverization is increased, muscovite, kaolinite, alloysite, beidellite, and montmorillonite show diffusional increase of their diffraction lines, hen disappear completely in x-ray patterns. Highly ground minerals become amorphous to -rays.

Attention is called to the following in Table : 1) in the mineral fraction, 200 mesh (cor-esponding to 0.074 mm diameters) of readily-oluble potassium is considerably greater than n the <0.01 mm diameter fraction, and is even <0.001 mm in diameter for micas; 2) the total otassium content in the <0.001 mm diameter raction of all minerals proved to be less than n the coarser fractions.

This phenomenon may be explained as follows: n the fraction <200 mesh which was obtained by rinding in the ball mill, a certain quantity of articles of colloidal dimensions which are ighly soluble in water and the salt solution re present. When the water of fraction <0.001 m in diameter was elutriated, these fine par-icles were dissolved. The second possibility, ased on Perkins' and other investigations (13), s that as a result of grinding not only dispersion of the minerals takes place, but a breakdown of their structure as well, with the consequent result that an alteration occurs in their properties, their chemical composition among others. The amorphous fraction of the mineral (the most soluble) is evidently richer in potassium than the remaining "skeleton" of this fraction (<0.001 mm in diameter).

Table 7 gives the results of chemical analysis of successive water extracts from the mineral fraction <0.001 mm in diameter obtained in water, and from mineral powder obtained after a 100-hour grinding in the ball mill and an additional two-hour trituration in an agate mortar. The ratio of minerals to water was 1:50. Reaction continued for 24 hours following the 1-hour agitation. After five water extracts, one carbonate extract was produced ($H_2O + CO_2$) during a six-hour flow of carbonic acid.

An increased solubility of the minerals (extraction of potassium), especially of microcline and biotite, resulted from the 100-hour grinding. Potassium was obtained by five successive water extracts: from microcline

Table 7

Solubility of minerals (potassium removal) by successive water extractions

Minerals	Diameter of particles, mm	Successive water extractions (1:50)						Carb. acid extraction (H_2O+CO_2)
		1	2	3	4	5	6	
		mg of K_2O/100 g of mineral						
Microcline	<0,001	46	—	—	—	—	—	—
"	Grinding 100 hrs	117	110	100	97	94	518	292
Muscovite	<0,001	181	63	57	44	43	388	158
"	Grinding 100 hrs	239	228	179	121	89	856	488
Biotite	<0,001	147	48	43	36	33	307	95
"	Grinding 100 hrs	641	221	186	128	83	1259	319

Note: Comma represents decimal point.

more than 5% of the total content, from muscovite more than 10%, and from biotite about 20%. By continuing with the water extracts, it would have been possible to obtain still more potassium. If we take into consideration the fact that the amount of very small particles (colloidal dimension) was small in the ground minerals, we must inevitably come to the conclusion that their solubility was very great. It should be noted that as much potassium was extracted from microcline as from muscovite and biotite. Grinding the minerals not only caused dispersion, but evidently still more profound alterations, causing their higher solubility.

Table 8 gives data of x-ray diffraction analysis of the clay fraction of the minerals studied (N. A. Sharina's analysis).[2] The d-spacings are expressed in Kx.

The x-ray pattern for fractions <0.001 mm in diameter give a typical picture characteristic of these minerals. In the mica x-ray patterns, especially of muscovite, after a two-hour additional trituration, a fading, increase of diffusion, and disappearance of a series of bright lines as well as an intensification of the background were observed. Consequently, in the mineral fractions following their grinding and trituration, along with the larger particles <0.001 mm in diameter a considerable quantity of particles of the colloid dimension (<1.5 Å) appeared. Grinding and trituration evidently had no effect on the lattice structure of microcline.

Figure 1 shows thermograms of minerals (B. M. Tunik's analyses). The thermograms of the fraction <0.001 mm diameter are in general typical for micas, but in both cases are weakly expressed in muscovite, while in biotite endothermic and exothermic effects at high temperatures are completely absent. The well defined effect at a temperature of 100°C indicates the high hydrophilic nature of the material and, consequently, its high dispersion. This may explain the low expression of the effect in the high temperature fraction of the x-ray patterns. The weak expression of effects in the fractions following grinding and trituration may be explained both by the small quantity of highly dispersed particles and their very high dispersion.

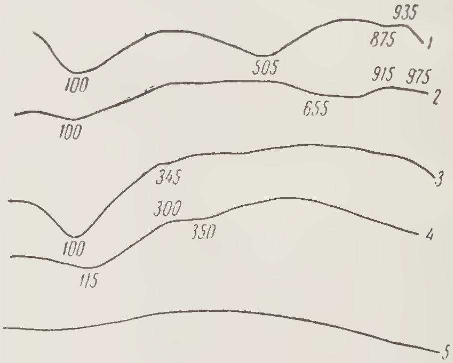

Fig. 1. - Thermograms of various mineral fractions.

1 - Muscovite fraction <0.001 mm diameter; 2 - Muscovite after 100-hr grinding and 2-hr trituration; 3 - Biotite fraction <0.001 mm diameter; 4 - Biotite after 100-hr grinding and 2-hr trituration; 5 - Microcline after 100-hr grinding and 2-hr trituration.

Chemical analyses, x-ray and thermal patterns thus establish the fact that as a result of prolonged grinding of minerals a fractional amorphization of the substances takes place. In connection with this a certain alteration of their chemical composition occurs

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[2] X-ray and thermal analyses of minerals were made in the mineralogical laboratory of the V. V. Dokuchayev Soil Institute, AS, USSR under the direction of N. I. Gorbunov.

Table 8

Effect of grinding and trituration of minerals on the d-spacing of their crystal lattices

Muscovite				Biotite				Microcline	
<0.001 mm diameter particles		100 hr grinding and 2 hr trituration		<0. 001 mm diameter particles		100 hr grinding and 2 hr trituration		100 hr grinding and 2 hr trituration	
Kx	I	Kx	I	Kx	I	Kx	I	Kx	I
11,68	6[a]	14,10	10	11,17	8[a]	—	—	12,70	10
10,05	10	10,70	—	9,98	10	9,98	8	7,49	
5,02	4	5,113	1	4,57	2	—	—	4,19	2
3,52	2	—	—	3,69	2	—	—	3,94	2
3,34	10	3,342	6	3,36	10	3,36	8	3,47	3
3,095	6	—	—	—	—	—	—	3,384	2
2,904	4	—	—	—	—	—	—	3,221	10
2,862	5	2,862	3	—	—	—	—	3,031	
2,783	5	—	—	2,74	4	2,74	1	2,894	3
2,594	7	—	—	2,61	4	2,61	4	2,774	2
2,568	7	2,568	5	—	—	—	—	2,634	
2,504	6	—	—	2,514	7	—	—	2,514	3
2,371	2	2,371	1	2,438	3	2,438	3	2,438	3
2,139	5	—	—	2,165	7	2,165	5	2,327	3
2,040	10	2,040	4	2,005	10	2,005	6	2,166	10
1,987	4	1,987	о. д.	1,920	2	—	—	1,993	5
1,801	8	—	—	—	—	—	—	1,920	5
1,728	2	—	—	—	—	—	—	1,869	5
1,693	2	—	—	1,670	9	1,670	7	1,802	10
1,647	7	1,647	5	—	—	1	—	1,662	2
1,555	7	1,554	6	1,530	9	1,530	8	1,579	3
1,519	—	—	—	—	—	—	—	1,521	4
1,498	10	—	—	1,472	2	—	—	1,480	1
1,448	3	—	—	—	—	—	—	1,459	8
1,367	8	—	—	—	—	—	—	1,433	5
1,352	8	1,392	4	1,357	9	1,380	5	1,413	5
1,297	4	1,355	2	1,329	5	1,347	3[a]	1,378	2
1,251	9	1,246	2	1,249	6	1,257	2	1,318	4
1,167	2	—	—	—	—	—	—	1,309	4
1,136	1[a]	—	—	1,133	4[b]	—	—	1.291	2
1,155	5	—	—	—	—	—	—	1,266	4[b]
—	—	—	—	—	—	—	—	1,196	3

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[a] Diffused line; [b] Broad line

Note: Comma represents decimal point.

vhich is accompanied by a considerable in-
rease in the solubility of minerals and an in-
rease in the availability of potassium from
hem.

Conclusions

1. All forms of soil potassium participate
1 the potassium nutrition of plants: intensive-
y exchangeable, extensively exchangeable, and
on-exchangeable. The less soluble the form
f potassium, the more active the role of the
lant itself in assimilating potassium.

2. The better the external conditions for the plant's development and growth, the greater the assimilative capacity (mobilizing capacity) of the plant: favorable media reaction, abundant water supply, abundant supply of air and nutritive elements, including potassium.

3. Under favorable nutritional conditions, plants are capable of assimilating a considerable quantity of soil potassium (non-exchangeable) from both sand and sandy loam soils, if there is a preponderance of primary potassium-bearing minerals (micas, feldspars) in the sand and silt fractions.

4. The abundant supplies of potassium in sierozems and chestnut soils are not only explained by the fact that they contain large amounts of exchangeable potassium, but also by the fact that the potassium-bearing minerals in their clay (colloidal) fraction (hydromicas, micas, and spars) are easily soluble and assimilated.

5. To study the composition and state of potassium-bearing minerals in the soil and their fertility characteristics as related to potassium, it is desirable not only to determine its available forms, but also its slightly-available forms by using acid extracts.

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CAPILLARY MOVEMENT OF MOISTURE IN STRATIFIED SOILS

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Soil moisture (its quantity, conditions, movement and accumulation, forms, and reaction with soil and plants) is a determining factor in soil fertility. The behavior of moisture has been primarily studied in homogeneous soils and considerably less in stratified grounds. Research in this field (2, 3, 4, 6) has dealt only with problems of moisture movement in stratified soils and has ignored capillary movement. There is an enormous amount of literature dealing with problems of movement and accumulation of moisture in soils.

Aware of the widespread occurrence of stratified soils in nature and the important scientific and economic significance of research concerning their hydrological properties, we have undertaken a study of the mechanics of moisture movement and salts in stratified soils. Laboratory research was begun in 1954 (7).

This report gives brief experimental results dealing with the height and rate of capillary rise of moisture in stratified soil. The experiment was done with glass tubes 2. 7 cm in diameter and 100 cm in height. Soil was placed in the tubes in layers of 2. 5 cm with a bulk density of 1. 4.

The materials used to form the stratified soil were as follows: 1) clay from the meadow soils of the Amu-Darya lowlands, (taken at a depth of 10-30 cm), 2) sand from channel deposits in the Amu-Darya lowlands (taken from a depth of 2 m), and 3) fine clay loam (loess) from the terrace of the Tashkent cycle. (Yu. A. Skvortsov) taken at a depth of 4 m. This material was triturated in a mortar and put through a sieve with a 1 mm mesh. The fractions of less than 1 mm in diameter were used to fill the tubes. An analytical characterization of the clay, loess, and sand is given in Tables 1, 2, 3, 4.

Figure 1 gives a diagram of the experiment. The following soil treatments are included: 1) uniform texture, 2) stratified by texture, coarser from bottom to top, 3) stratified by texture, finer from bottom to top, 4) stratified, with mixed distribution of layers, varying in texture.

Results of the experiment are given in Tables 5 and 6. An analysis of the materials makes it possible to ascertain the exceptional effect of soil stratification on the height and rate of the capillary movement of moisture.

Capillary movement of moisture in soil treatments of uniform texture was found in our experiment to be in complete accord with the classical concepts of this movement in porous media and requires no special discussion in this article (Fig. 2). The following, however, should be noted:

1. The assumption that the initial portions of the capillary rise curves approach parabolas (5) was corroborated in our experiment only for the clay column. In the clay loam, and especially the sand columns the capillary rise curves deviate considerably from curves of the parabolic type. The relationship of the height of capillary rise of moisture to time is consequently in conformity with another law for coarser textured soils.

2. The rate of capillary movement of moisture in a uniform soil texture is evidently somewhat related to the thickness of the soil layer in which the movement occurs, in addition to other factors. This is suggested by the tendency toward an increase in the rate of the capillary rise of moisture as the thickness of the column is reduced, which we observe in the treatments: 1, 2 — 3, 4 — 3, 4 — 5, 6 — 7, 8 — 23, 24 — 25, 26 — 27, 28 — 29, 30 (Table 6). The effect of the thickness of the column on the rate of capillary movement of moisture is so insignificant, however, that there is no basis to speak of its practical significance, just as there is no basis to maintain that this phenomenon does not exist. We connect the cause of a certain decrease in rate of capillary rise of moisture when there is an increased thickness of the column with air

Table 1

Particle size analysis (pipette method; sample processed with sodium hexametaphosphate)[a]

Sample	Weight of fractions, %							
	>0,25	0,25–0,10	0,10–0,05	0,05–0,01	0,01–0,005	0,005–0,001	<0,001	Physical clay
Clay	1,36	0,59	5,74	6,65	22,66	38,45	24,55	85,66
Loess	0,37	0,29	11,29	40,65	26,00	10,75	10,65	47,40
Sand	0,47	6,46	57,67	32,25	1,45	0,25	1,45	3,15

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[a] Analyst: V. P. Maskina

Note: Comma represents decimal point.

Table 2

Microaggregate analysis (N. A. Kachinskiy's method)[a]

Sample	Weight of fractions, %							
	>0,25	0,25–0,10	0,10–0,05	0,05–0,01	0,01–0,005	0,005–0,001	<0,001	Physical clay
Clay	0,70	0,60	3,90	28,00	24,60	33,80	8,40	66,80
Loess	0,30	0,30	8,70	63,90	14,20	9,20	3,40	26,80
Sand	0,40	1,80	73,50	23,30	0,20	0,20	0,60	1,00

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[a] Analyst: L. Ye. Shapavalova

Note: Comma represents decimal point.

Table 3

Humus content and composition of water extract in % per air dry soil[a]

Sample	Humus	Solid residue	Leaching		Cl^-	SO_4^{--}	Ca^{++}	Mg^+	$Na^+ + K^+$
			from CO_3	from HCO_3					
Clay	1,22	0,412	None	0,026	0,088	0,138	0,034	0,017	0,061
Loess	0,17	0,104	0,014	0,045	0,007	0,025	0,014	0,004	0,009
Sand	0,19	0,314	None	0,016	0,081	0,093	0,022	0,009	0,060

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[a] Analyst: N. F. Alekseyenko

Note: Comma represents decimal point.

friction on the soil particles when they are displaced by a thicker soil layer.

The capillary movement of moisture in stratified soil is very complex and peculiar. According to graphs which show the relationship of height of capillary rise to time of movement, compiled on the data of Table 5, it is established that capillary movement of moisture in stratified soil does not have the same attenuating characteristics that are observed in uniform textured soil. On the contrary, in the curves of

Table 4

Data on physical properties

Sample	Particle density	Bulk density	Porosity, %	Maximum hygroscopic moisture[a]
Clay	2,66	1,40	47,40	7,26
Loess	2,65	1,40	47,20	3,87
Sand	2,65	1,40	47,20	2,96 (?)

[a] Determined by M.U. Umarov

Note: Comma represents decimal point.

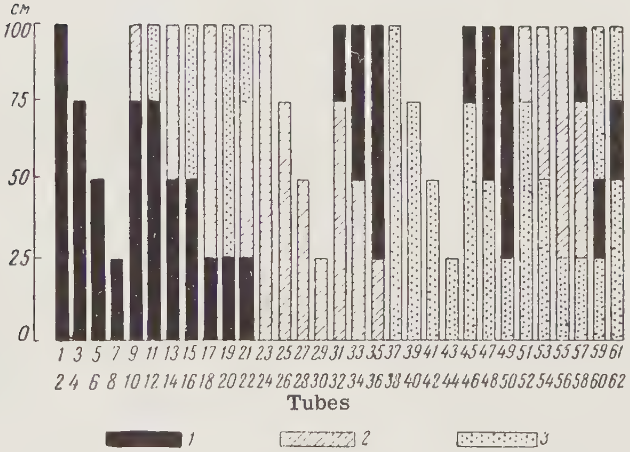

Fig. 1. - Diagram of experiment.

1 - clay; 2 - sandy loam; 3 - clay

his relationship there are breaks; their locaion is coordinated with the boundaries of the sections between layers. These breaks are vident (Fig. 3) in the curves of capillary rise f moisture in soil with stratification which in exture becomes coarser from bottom to top, nd also with mixed distribution of layers hich differ in texture.

In stratified soil which is finer in texture rom bottom to top, the same is observed. This s not directly evident from the graphs showing elationship between height of capillary rise to ime of movement, but is evident from the urves compiled according to the logarithms of eight and time.

Observations of capillary movement of moisure have shown that in stratified soils of a texure that is coarser from bottom to top, there ccurs temporary cessation of moisture movenent in the boundaries of the sections between strata. These cessations will be more prolonged the higher the section is located above the free moisture surface and the greater the difference in the texture of the strata (Table 5, numerals in parentheses). We observed the same phenomenon in test experiment (7). We shall explain the causes of this below.

The graphs of relationship between height of capillary rise of moisture and time of movement (Figs. 3 and 4) express clearly the effect of stratified soil on this height. If the lowest layer in stratified soil is fine in texture and the upper layer coarse, the height of the capillary rise of moisture which terminates in the upper layer will be less than in uniform textured soil to a limited thickness of the lower layer). With reversed distribution of layers the height of capillary rise of moisture will be greater than in the same uniform textured material. The greater the difference in the texture of the combined layers, and the thicker the lower layer,

Table 5

Height of capillary rise of water in soils of various formation in relation to rate of movement, in hours (average for two replicates)

Height from water surface, cm	Tube numbers															
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32
100	1991	—	—	—	2471	5736	1860	8268	1371	5414	4558	143	—	—	—	240
95	1757	—	—	—	2215	4130	1680	6119	1246	3720	2945	128	—	—	—	181
90	1572	—	—	—	1965	3195	1518	4753	1133	3000	2430	114	—	—	—	141
85	1391	—	—	—	1748	2550	1373	3760	1030	2450	2085	100	—	—	—	110
80	1227	—	—	—	1540 (174)	2030 (429)	1235	2961	931	2050	1680 (438)	88	—	—	—	88
75	1079	1071	—	—	1151	1107	1110	2289	836	1715	828	77	71	—	—	76
70	945	929	—	—	1012	975	988	1780	742	1450	725	67	62	—	—	65
65	813	789	—	—	875	837	879	1385	645	1212	640	57	53	—	—	54
60	694	672	—	—	742	705	770	1039	565	997	560	49	46	—	—	48
55	584	567	—	—	618	600	665 (66)	832 (198)	490	815	493	41	38	—	—	40
50	490	472	496	—	519	492	489	471	421	663	421	34	32	33	—	33
45	400	385	388	—	416	403	396	390	357	528	354	28	27	27	—	27
40	318	305	305	—	327	318	315	306	290	408	292	23	21	22	—	22
35	237	231	228	—	238	234	234	225	230	302	230	17	16	16	—	17
30	175	167	166	—	172	170	169	166	176 (7)	217 (50)	178 (11)	13	12	12	—	13
25	120	115	113	116	119	117	112	113	110	101	114	9	8,4	8,4	8,7	9,2
20	76	73	70	71	72	74	70	72	68	62	71	6,1	5,5	5,5	5,7	6,0
15	42	40	38	40	40	40	38	40	38	34	39	3,6	3,3	3,1	3,2	3,7
10	19	18	17	17	18	19	17	19	17	15	18	1,9	1,6	1,5	1,5	1,8
5	5,1	5,2	4,8	4,7	5,1	5,5	4,5	5,5	4,6	4,0	4,8	0,6	0,5	0,4	0,4	0,5

Note: Comma represents decimal point.

Table 5, (continuation)

Height from water surface, cm	Tube numbers														
	33 34	35 36	37 38	39 40	41 42	43 44	45 46	47 48	49 50	51 52	53 54	55 56	57 58	59 60	61 62
100	618	1162	74	—	—	—	164	590	1190	34	40	79	179	5394	2630
95	501	997	50	—	—	—	112	468	1013	30	34	68	126	3450	1514
90	405	854	34	—	—	—	71	366	873	25	28	58	87	2610	942
85	319	729	24	—	—	—	43	278	743	21	22	49	62	2030	558
80	240	611	18	—	—	—	26	192	617	17	18	41	45	1562	348
															(76)
75	176	512	13	14	—	—	19	137	512	13	14	34	35	1200	132
70	127	415	9,9	10	—	—	15	90	416	11	11	27	29	922	86
65	91	324	7,5	7,5	—	—	12	53	330	8,5	8,4	22	23	667	51
60	64	248	5,7	5,7	—	—	9,6	29	250	6,6	6,6	17	19	465	27
55	47	180	4,3	4,4	—	—	7,7	15	183	5,2	5,2	13	14	300	13
														(65)	
50	36	128	3,2	3,3	3,7	—	6,1	9,8	120	3,9	4,2	9,4	11	117	7,5
45	30	85	2,5	2,6	2,7	—	4,8	8,0	76	3,0	3,2	6,4	7,6	74	6,3
40	24	52	1,8	1,9	2,0	—	3,7	6,5	44	2,3	2,5	4,2	5,3	42	5,1
35	19	30	1,4	1,4	1,4	—	2,9	5,1	22	1.7	1,9	2,6	3,7	20	3,9
30	15	16	0,9	1,0	1,0	—	2,1	3,9	8,6	1,2	1,4	1,6	2,6	6,4	2,9
25	10	9,0	0,6	0,7	0,7	0,7	1,6	2,9	3,5	0,8	0,9	1,1	1,9	2,0	2,3
20	7,2	6,1	0,4	0,4	0,4	0,4	1,0	2,0	2,4	0,6	0,6	0,8	1,3	1,5	1,6
15	4,5	3,7	0,2	0,2	0,2	0,2	0,6	1,2	1,4	0,3	0,4	0,5	0,8	0,9	0,9
10	2,2	1,9	0,1	0,1	0,1	0,1	0,2	0,5	0,8	0,2	0,2	0,3	0,4	0,5	0,4
5	0,7	0,6	0,03	0,03	0,03	0,03	0,05	0,07	0,1	0,05	0,06	0,08	0,08	0,1	0,08

Note: The numerals in parentheses show duration of capillary rise of water in boundaries of sections of soil materials, in hours.

Note: Comma represents decimal point.

Table 6

Rate of capillary rise of water in soils of various texture at varying heights of capillary rise, cm/hr
(average from two replicates)

Height from water surface, cm	Tube numbers															
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32
95—100	0,021	—	—	—	0,019	0,003	0,027	0,002	0,040	0,003	0,003	0,33	—	—	—	0,085
90—95	0,026	—	—	—	0,020	0,005	0,031	0,004	0,044	0,007	0,009	0,36	—	—	—	0,12
85—90	0,028	—	—	—	0,023	0,007	0,034	0,005	0,048	0,009	0,014	0,36	—	—	—	0,15
80—85	0,031	—	—	—	0,024	0,010	0,036	0,006	0,051	0,013	0,012	0,41	—	—	—	0,23
75—80	0,034	—	—	—	0,023	0,011	0,040	0,007	0,053	0,015	0,012	0,45	—	—	—	0,42
70—75	0,036	0,035	—	—	0,036	0,038	0,041	0,010	0,053	0,019	0,048	0,50	0,56	—	—	0,45
65—70	0,038	0,036	—	—	0,036	0,034	0,046	0,013	0,051	0,021	0,059	0,50	0,56	—	—	0,45
60—65	0,042	0,043	—	—	0,038	0,038	0,046	0,012	0,063	0,023	0,062	0,62	0,71	—	—	0,83
55—60	0,045	0,047	—	—	0,040	0,047	0,047	0,024	0,067	0,027	0,075	0,62	0,63	—	—	0,63
50—55	0,053	0;053	—	—	0,050	0,046	0,045	0,030	0,073	0,033	0,069	0,71	0,83	—	—	0,71
45—50	0,056	0,057	0,046	—	0,051	0,056	0,054	0,062	0,079	0,037	0,075	0,83	1,00	0,83	—	0,83
40—45	0,061	0,062	0,060	—	0,056	0,061	0,062	0,059	0,075	0,042	0,081	1,00	0,83	1,00	—	1,0
35—40	0,062	0,065	0,065	—	0,056	0,060	0,062	0,062	0,083	0,047	0,081	0,83	1,00	0,83	—	1;0
30—35	0,081	0,078	0,082	—	0,076	0,079	0,074	0,085	0,093	0,059	0,096	1,2	1,2	1,2	—	1,2
25—30	0,091	0,96	0,094	—	0,094	0,094	0,088	0,094	0,085	0,076	0,094	1,2	1,3	1,3	—	1,3
20—25	0,11	0,12	0,12	0,11	0,11	0,12	0,12	0,12	0,12	0,13	0,12	1,7	1,7	1,7	1,7	1,6
15—20	0,15	0,15	0,15	0,16	0,15	0,15	0,16	0,16	0,17	0,18	0,16	2,0	2,3	2,1	2,0	2,2
10—15	0,22	0,23	0,24	0,22	0,26	0.24	0,24	0,24	0,24	0,26	0,24	2,9	2,9	3,1	2,9	2,6
5—10	0,36	0,38	0,41	0,41	0,39	0,37	0,40	0,37	0,40	0,46	0,38	3,8	4,5	4,5	4,5	3,8
0—5	0,98	0,93	1,00	1,10	0,98	0,90	1,10	0,90	1,10	1,20	1,00	8,3	10,00	12,5	12,5	10,0

Note: Comma represents decimal point.

Table 6 (continuation)

Height from water surface, cm	Tube numbers														
	33 34	35 36	37 38	39 40	41 42	43 44	45 46	47 48	49 50	51 52	53 54	55 56	57 58	59 60	61 62
95 — 100	0,043	0,031	0,21	—	—	—	0,096	0,041	0,028	0,36	0,83	0,45	0,094	0,003	0,005
90 — 95	0,052	0,035	0,31	—	—	—	0,12	0,049	0,036	1,0	0,83	0,50	0,13	0,006	0,009
85 — 90	0,059	0,040	0,50	—	—	—	0,18	0,057	0,036	1,3	0,83	0,56	0,20	0,009	0,013
80 — 85	0,063	0,042	0,83	—	—	—	0,29	0,058	0,039	1,3	1,2	0,62	0,29	0,011	0,024
75 — 80	0,078	0,051	1,2	—	—	—	0,72	0,091	0,048	1,3	1,2	0,71	0,50	0,014	0,036
70 — 75	0,10	0,052	1,6	1,2	—	—	1,2	0,11	0,052	2,5	1,7	0,71	0,83	0,021	0,11
65 — 70	0,14	0,055	2,1	2,0	—	—	1,7	0,14	0,058	2,0	1,9	1,0	0,83	0,020	0,14
60 — 65	0,18	0,066	2,8	2,3	—	—	2,1	0,21	0,063	2,6	2,8	1,0	1,2	0,025	0,21
55 — 60	0,29	0,074	3,6	3,8	—	—	2,6	0,36	0,075	3,6	3,6	1,2	1,0	0,030	0,36
50 — 55	0,45	0,096	4,5	4,5	—	—	3,1	0,96	0,079	3,7	5,0	1,4	1,7	0,042	0,91
45 — 50	0,83	0,12	7,1	7,2	5,0	—	3,8	2,8	0,11	5,6	5,0	1,7	1,5	0,12	4,2
40 — 45	0,83	0,15	7,1	7,2	7,1	—	4,5	3,3	0,16	7,1	7,1	2,3	2,2	0,16	4,2
35 — 40	1,0	0,23	12,5	10,0	8,3	—	6,3	3,6	0,23	8,3	8,3	3,1	3,1	0,23	4,2
30 — 35	1,2	0,36	10,0	12,5	12,5	—	6,3	4,2	0,37	10,0	10,0	5,0	4,5	0,37	5,0
25 — 20	1,0	0,72	17	17	17	—	10,0	5,0	0,99	12,5	10,0	10,0	7,2	1,1	8,3
20 — 25	1,8	1,7	25	17	17	17	8,4	5,6	4,5	25	17	17	8,3	10,0	7,2
15 — 20	1,9	2,1	25	25	25	25	12,5	6,3	5,0	17	25	17	10,0	8,3	7,2
10 — 15	2,2	2,8	50	50	50	50	12,5	7,1	8,3	50	25	25	12,5	12,5	10,0
5 — 10	3,3	3,8	72	72	72	72	26	11,6	7,1	33	36	23	15,6	12,5	15,7
0 — 5	7,2	3,3	167	167	167	167	100	72	50	100	83	62	62	50	63

Note: Comma represents decimal point.

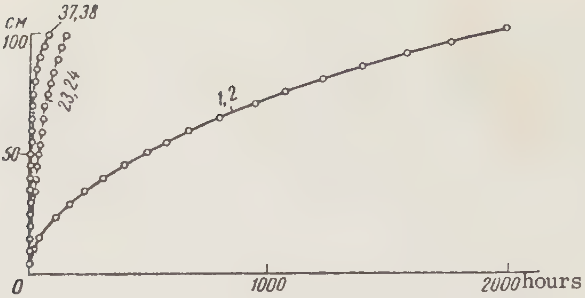

Fig. 2. - Relationship of height of capillary rise of water in various soils textures to rate of movement.

1, 2 - clay column (100 cm); 23, 24 - loess column (100 cm); 37, 38 - sand column (100 cm).

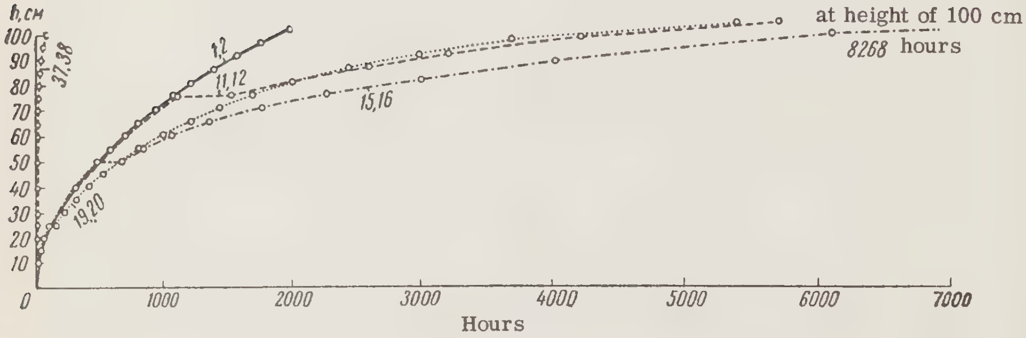

Fig. 3. - Relationship of height of capillary rise of water to time of capillary movement in various uniform soil texture.

1, 2 - uniform clay column 100 cm; 37, 38 uniform sand column, 100 cm; 19, 20 - stratified column, clay 25 cm, sand 25-100 cm; 15, 16 - stratified column, clay 0-50 cm, sand 50-100 cm; 11, 12 - stratified column, clay 0-75 cm, sand 75-100 cm.

the greater will be the deviation of heights of capillary rise of moisture in stratified soil as compared with uniform soil (to a limited thickness, however, of the lower layers. Table 5).

Soil texture: particle size distribution of the combined layers and their thickness thus effect substantially the height of capillary rise of moisture. The latter depends not only upon the effective diameters of the capillaries and the degree of moistening of the layer in which the capillary rise of water terminates, but also upon the effective diameter of the capillaries of all the soil layers within the capillary border. Reduction in the height of capillary rise in the upper, coarse layers, caused by the fine-textured lower layers (as compared with the height of capillary rise in the columns of uniform soil, represented by materials of the upper layer), and the increase in the height in the upper heavy layers, caused by the coarser textured lower layers (these heights depend upon the thickness of the lower layer), suggest that friction has an effect on the height of capillary rise. Jouren's formula, which does not take friction into consideration, cannot therefore be used in calculating height of capillary rise of water, especially in fine-textured soil. This formula is useful, within certain probability limits, for calculating heights of capillary rise only in coarse textured soil. Rode also indicates this (5).

The height of capillary rise of water is thus determined by the relationship of the stimulating and impeding factors of capillary rise which occur in one or another section of the soil. Meniscus forces pertain to the former, the weight of the accumulated water column and evident friction between the free and bound water pertain to the latter. The mixture height of capillary rise of water in the soil is consequently conditioned by the equilibrium created between the stimulating and impeding factors of capillary rise.

The height of capillary rise of water in soil, however, does not depend solely upon the

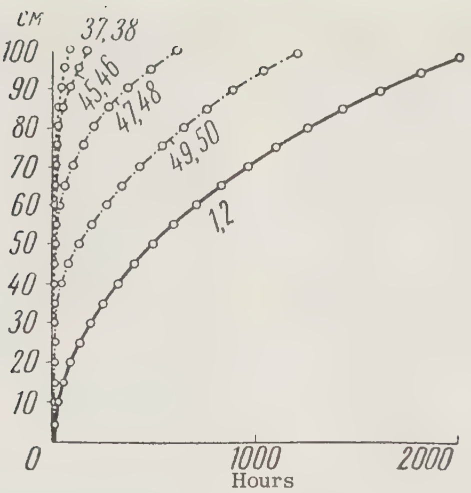

Fig. 4. - Relationship of height of capillary rise of water to time of movement in varying soil texture.

1, 2 - clay column 100 cm; 37, 38 - sand column 100 cm; 49, 50 - stratified column, sand 25 cm, clay 25-100 cm; 47-48 - stratified column - sand 0-50 cm, clay 50-100 cm; 45, 46 - stratified column sand 0-75 cm, clay 75-100 cm.

relationship of these factors, but upon other factors as well. We reached this conclusion from a comparison of curves for height of capillary rise of water in relation to the rate of its movement in soil, with layers, the texture of which becomes finer from the bottom upwards with a different relationship of the upper and lower layers. It appears that the curve of derived height for the rate of capillary movement of water in the finer-textured layers of such soil decreases as the thickness of the lower layers increases. There are evidently two causes for this phenomenon: 1) as the thickness of the lower layer increases, friction is to a certain extent increased, and 2) because of the balance of capillary moisture accumulating at one or another height, its intake and expenditure in evaporation and bound water (as the amount of capillary water taken up in the soil) decreases with height, while its relative expenditure ultimately increases. The effect of the latter factor on the height of capillary rise may be judged by data from another of our experiments. A column 100 cm high consisted of layers of three materials: on the bottom, a noncarbonate fine clay loam (0-25 cm), in the center, quartz sand (25-75 cm, <0.25 mm diameter particles), and above, the same fine clay loam (75-100 cm). The capillary rise of water in this column stopped at a height of 75 cm, i. e. at the boundary of the division between the sand and the upper layer of fine clay loam. We continued to watch for a movement of water in this column for a period of six months; no capillary rise of water from the sand to the fine clay loam took place, however. Breaking the tube, and determining the soil moisture in each 5 cm layer, we were convinced that capillary moisture was present in the sand at the boundary of the layer, whereas only bound water was present in the fine clay loam. Thus the entire amount of capillary moisture taken through the lower layer to the upper was consumed in the latter by bound water and evaporation. This factor is of great significance in stratified soil, as in the event of fine-textured layers at the bottom and coarse textured layers above, with a given thickness of the lower layers, the capillary fringe, when effected by friction, may be so constricted that the boundary of the layer may be the limit for the capillary rise of water. This takes place not only because the meniscus forces in the upper layer are unable to overcome the over-all friction factors and the entire water column, but also because at the boundary of the layer the intake of capillary moisture is equal to the expenditure.

In soil with a reversed distribution of layers the boundary of the layer is also the maximum height of capillary rise of water, in spite of the fact that the meniscus forces, (if menisci can form in the upper layer), would be able to bring about further capillary rise of water.

In another of our experiments a factor which effecting the height of capillary rise of water in stratified soil became apparent. It was observed that in a soil column with a sandy layer lying beneath the fine clay loam, capillary rise of water in the upper layer may to a certain extent continue, even when the meniscus forces in the upper layer would appear to be unable to overcome the total friction factors and the entire water column. The cause of this was ascertained by a special experiment and consisted in the fact that on the boundaries of the layer, capillary rise of moisture, as a result of the irrational pores in the lower and upper layers, was forced to stop in spite of the fact that the meniscus forces were able to further the capillary rise of the water. This causes the water pressure from below, no longer equilibrated by an increase in the water column, to act on the water meniscus in the soil pores of the lower layer and also on the boundary of the layer underlying them. A certain additional quantity of water, however, enters the soil and overcomes the friction forces and the water column, creating a partial basis for capillary phenomenon in the upper layer. This factor somewhat effects the height of the capillary rise of water in stratified soil. It also probably occurs in uniform soil owing to the reciprocal structure of capillaries in it. With this, as well as with the causes of temporary cessation of capillary rise in the boundaries of the layers, we connect the staggered capillary movement of water in porous media.

The values for rate of capillary rise of water given in Table 6 suggest that these rates are related to the texture of the layers, to their thickness and reciprocal distribution in soil. As the texture of the layers becomes coarser from below upwards, there is a tendency toward increase in rate of capillary movement of water in the lower layers as compared with the rate of water rise in a uniform soil. In the upper layers, an abrupt decrease in rate occurs (Table 6). An increase in the thickness of the lower layers causes a still greater decrease in the rates of the upper layers and a less well-defined increase in the lower layers.

In stratified soil with a reverse distribution of textured layers, the rate of capillary movement of water in the lower layers decreases as compared with the rates of movement in the same materials with uniform texture, while in the upper layers it increases (only, however, to a certain thickness of the lower layers, Table 6). An increase in the thickness of the lower layers brings about a less abrupt increase or decrease in rates in corresponding layers. We may conclude that the rate of

Table 7

Variation in rate of capillary rise of water in sand layers of soils effected by air friction, cm/hr

Height above free water level, cm	Soil texture, cm						
	Sand 100 cm	Sand			Sand		
		0–25	0–50	0–75	0–25	0–50	0–75
		Clay			Loess		
		25—100	50–100	75—100	25—100	50–100	75–100
0–5	167	50	72	100	62	83	100
5—10	72	7,1	11,6	26	23	36	33
10—15	50	8,3	7,1	13	25	25	50
15—20	25	5,0	6,3	12	17	25	17
20—25	25	4,5	5,6	8,4	17	17	25
25—30	17	Clay	5,0	10,0	Loess	10,0	12,0
30—35	10	"	4,2	6,3	"	10,0	10,0
35—40	12	"	3,6	6,3	"	8,3	8,3
40—45	7,1	"	3,3	4,5	"	7,1	7,1
45—50	7,1	"	2,8	3,8	"	5,0	5,6
50—55	4,5	"	Clay	3,1	"	Loess	3,7
55—60	3,8	"	"	2,6	"	"	3,6
60—65	2,8	"	"	2,1	"	"	2,6
65—70	2,1	"	"	1,7	"	"	2,0
70—75	1,6	"	"	1,2	"	"	2,5

Note: Comma represents decimal point.

movement of water in stratified soil also depends upon the relationship of the stimulating and impeding factors of this movement, and upon the balance or capillary water at that or any other height.

In addition, the decrease in rate of capillary rise of water in the lower soil layers in which the texture becomes finer from below upwards, as compared with the rates of water passage in the same material with uniform texture, suggests that air displaced by the capillary water also impedes the rate of movement. As the thickness of the upper, finer-textured layer increases, the rate of the capillary movement of water in the lower layer decreases. This indicates that the impeding of the capillary rise of water in the lower layers is due to the force of air friction on the soil particles when displaced by the capillary water. A greater impeding of the capillary rise of water in the lower layers when there is a finer-texture in the upper layers also indicates this (Table 7).

The cause of the temporary cessation of the capillary rise of water at the boundaries of the sections between the fine-textured layers below and the coarse textured layers above is the irrationality of the pores of the lower and upper layers. Owing to this, the water taken up as far as the boundaries of the section is only partially taken into the upper layer where, in turn, it is quickly expended in evaporation and also becomes bound. The saturation process in the upper layers by bound water (which takes place with the participation of condensed moisture also) occurs, evidently, until the bound water which is in contiguity with the menisci in the pores of the lower layer forms menisci in the larger pores of the upper layer. It is at this stage of saturation that the temporary cessation at the boundaries of the section ceases.

In soil with mixed distribution of layers of varying texture the movement of water occurs under the influence of the same forces and factors, but in different quantitative proportions, caused by the peculiarities of the soil stratification. In conclusion it should be pointed out that the opinion that the capillary characteristics of stratified soil are poorer than in uniform texture was in general not verified by our experiments. In many instances the opposite was observed, (Table 5, treatments 37, 38-51, 52-53, 54).

Further research in the physics of stratified soil will help clarify many unsolved problems concerning soil genesis and agricultural practices.

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SOME PECULIARITIES REFLECTING SOIL EROSION PROCESSES IN SURFACE LAYERS OF RECENT PEAT BOGS

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While doing research in agricultural peat lands in the central zone of the European part of the Russian Socialist Federative Soviet Republic, (RSFSR), we became aware of the fact that the morphology and chemical properties of the upper layers of recent peat bogs have peculiarities which are not common to the underlying basic peat horizon. In these we find that the mechanical admixture of the sand, clay-materials and clay particles is increased, the ash content of the peat is greatly increased, and substantial changes in the ash composition, as compared with the underlying layers, are to be observed. Analysis of the materials shows that an effect of the water and wind erosion processes occur here, combined with land cultivation.

A characteristic feature of the normal peat forming process is the formation of organic peat substances without clearly defined mineral inclusions or traces. The mineral (zonal) fraction of peat is bound, as a rule, with the organic fraction constitutionally, becoming part of the remaining texture of plant-peat formation constituents, or saturating the adsorption complex of peat through the cations.

In the high-ash type of peat formation, morphologically isolated mineral inclusions or traces of various magnitudes appear in the layer. These are formed as the result of chemical, mechanical, or biogenous sedimentation of soil mineral deposits, alluvial waters and surface run-off waters, or from the atmospheric dust (1, 3). The products of primarily chemical and biogenous sedimentation consist of inclusions and traces of lime, vivianite, siderite, and ochre found in peat deposits. The products of mechanical sedimentation consist of inclusions of sand, clay-material and clay particles. When there is a maximum expression of the mineral sedimentation processes, the peat forming process may cease completely and the surface of the peat deposit is partially or entirely covered with mineral deposits, the so-called "mineral sediments."

The development of the soil erosion processes, especially by water, in the European territories of the RSFSR could not do other than effect the peat deposits which lie in the lower relief sections. These processes have created a zone of mass mineral sediment development on the surface of recent bogs.

Based on materials edited by the Main Administration for Peat Lands (6), the occurrence of peat deposits with mineral sediments was compiled for a series of regions and autonomous republics in the European part of the RSFSR. Average data obtained are given in Table 1, and a diagram of the occurrence of deposits with mineral sediments (on the basis of data calculated for each administrative area) is shown in Figure 1.

A zone is distinguished in which peat deposits with mineral sediments comprise 50%-100% of the total for a given administrative area (Kursk, Orlovsk, Belgorod, a large section of Voronezh, Tambov regions, and various areas of several other regions).

A comparison of the diagram with the map "Soil-Erosion Areas of the USSR," compiled by S. S. Sobolev, I. F. Sadovnikov and others, and published in 1957, shows the coincidence of a large part of this territory with the soil-erosion area where the percentage of eroded soils amounts to 10%-20% of the total area of cultivated and abandoned plowlands and pastures.

The territories with a broad (but not continuous) distribution of peat deposits with mineral sediments (right bank of the Volga in Gor'kov region, eastern section of the Bryansk, areas of the Tatar, Mordov, and Udmurt ASSRs, Penzen, Ul'yanov, and Ryazan areas, etc.), fall into the soil erosion areas which have 5%-10%, and partially 10%-20%

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[1] Presented at the First Conference of Soil Science Delegates, May 1958.

Table 1

Occurrence of peat deposits with mineral sediments

Regions and republics	Percentage of peat deposits with mineral sediment of total number of lowland type of peat deposits (average)
Tombov, Orlov, Voronezh, Belgorod, Kursk	66
Tatar ASSR, Ul'yanovsk, Kuibvshev, reg. Mordov ASSR	33
Udmurt ASSR, Gor'kov, Ryazan, Penza, Tula, Bryansk	11
Smolensk, Moscow, Kostroma, Vladimir, Yaroslav	2.2
Leningrad, Novgorod, Pskov, Kalinin	<1

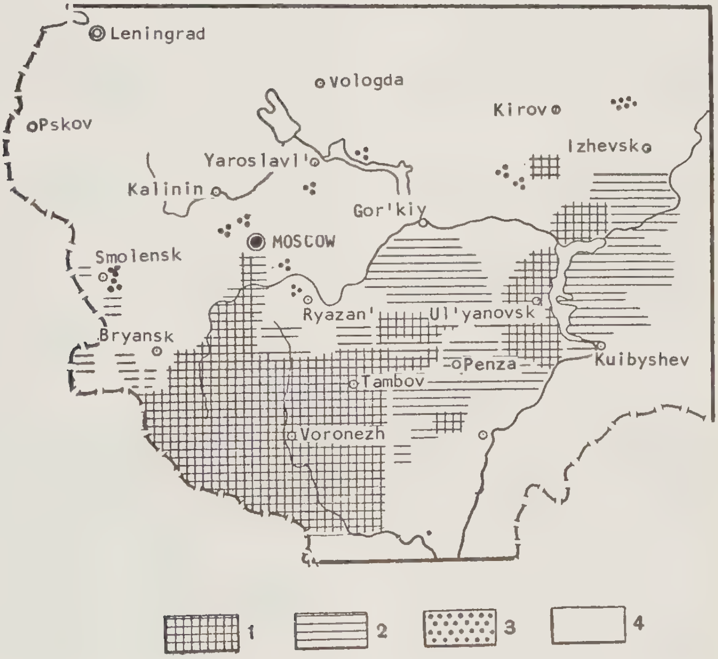

Fig. 1. - Occurrence of peat deposits with mineral sediments in the European territories of the RSFSR. Peat deposits with mineral sediments are comprised of the total number of deposits of the lowland type for the following territories:

1 - 50%-100%; 2 - 10%-50%; 3 - 1%-10%; 4 - less than 1%.

eroded soil.

Individual distributions of peat deposits with mineral sediments, such as the areas of the Smolensk-Pochinkov highlands in Smolensk region, the central part of the Bryansk region, and several others, are connected with the soil erosion areas in which the percentage of eroded soils constitutes 5%-10%.

Areas which have a minimum of peat deposits with mineral sediments belong to the soil erosion areas with a preponderance of slight erosion.

Table 2

Ash content in upper and lower layers of peat layers in upland sections of large peat deposits

Name of peat deposits	Area of upland sections, hectares	% of ash content for abs. dry material				No. of borings
		Upper layer		Basic horizon		
		Average values	Bore variation	Average values	Bore variation	
Ignatov, Kaluga regions	1250	6.8	2.1-12.8	3.0	2.0-5.0	74
Tesova-Netyl'sk, Novgorod regions	6000	4.2	2.4-5.8	2.8	1.9-4.7	23
Ulomskoye III, Vologda region	7100	4.7	2.2-8.3	3.2	2.3-7.1	55

The average thickness of the mineral sediments in maximum development centers of such peat deposits amounts to about a half meter, although the maximum thickness may exceed 1.5 m and more. Such thickness of sediments is characteristic of deposits lying in rather wide bottom lands.

In areas with narrow bottoms of the ravine type, and in ravine peat layers, the thickness of the sediment is considerably greater. For example, in the Bryansk area ravine, peat deposits have been measured which have mineral sediments of more than 3.8 m and in the Kursk area — of more than 4 m.

The effect of wind erosion is manifested primarily in the form of sand and silt admixture in the upper peat layer. Even the great masses in the upper relief forms which exclude mechanical admixtures brought about by water currents are effected by wind erosion. In many places they have a considerably greater ash content in the upper layer than exists in the underlying layers (Table 2).

Attention is called to the unusually high index of ash content in the upper layer of the Ignatov deposit which encircles the plowed lands on the southern boundary of the upland type of peat deposit.

For further study we used materials dealing primarily with small peat deposits from various areas of the Moscow, Vladimir, Bryansk, and Smolensk regions. Lying in small depressions, with comparatively large water collecting areas, and often encircling plowlands, these small peat deposits undergo unusually heavy surface and wind erosion.

Mineral sediments occur not only in peat deposits in river bottoms, but in deposits in watershed troughs, and not only in lowland deposits, but in the upland and transition deposits as well. When peat deposits are very small and are in the immediate vicinity of fields, they may be completely buried; more frequently, however, the mineral sediments form a belt around the central part, thus creating central and end zones which differ in vegetation cover, microrelief, and moisture.

The most characteristic features of the upper layers of the deposits are the abrupt increase in ash content and the change in ash composition. Even where there are no clearly expressed mineral sediments, there is an increase in the ash content of the upper layer.

Figure 2 shows stratigraphic cross sections and the rate of depth changes of ash content, CaO content, and the insoluble mineral ash residue in three small peat deposits of the Moscow region. These peat deposits are found in the watershed depressions of the Klin-Dmitrov and Volokolamsk moraine uplands. The "Ozerskiy" deposit (lowland type) consists of lowland forest bog- and forest peat in the upper meter and a half layer. Below it lies slightly-decomposed lowland bog peat (primarily gypsum). In the bottom horizon is found a more decomposed woody-gypsum peat. The average depth of the deposit is about six meters.

The "Gorelyi" deposit has the following structure: a 12 cm layer of Sphagnum medium which is mixed with a large amount of sand. Beneath this is medium- and well-decomposed pine-sphagnum, pine, and pine-Eriophorum peat which is replaced by poorly-decomposed medium peat at a depth of 1.25 m. The bottom horizon is horsetail peat. The deposit is about 2 m deep. Notwithstanding its small thickness, the deposit is very old (end of the Holocene).[2]

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[2] Age determined by spore-pollen analysis.

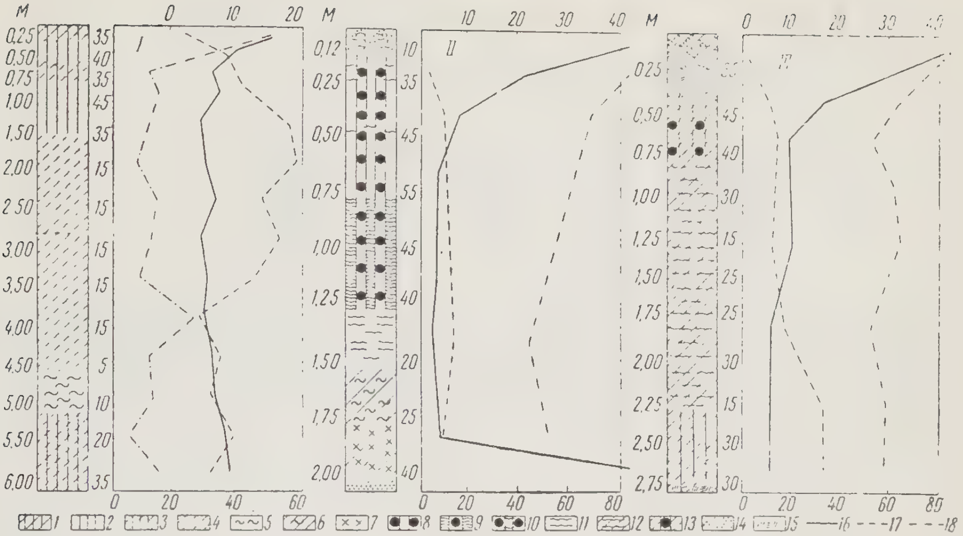

Fig. 2. - Stratigraphy and depth determination of ash content, CaO, and insoluble mineral ash in peat deposits; "Ozerskiy" (I), "Gorelyi" (II), "Lopotovo" (III)

1-7 Lowland peat types: 1 - woody-sedge; 2 - woody; 3 - woody-gypseous; 4 - gypsum; 5 - lowland sphagnum; 6 - lowland sedge-sphagnum; 7 - horsetail; 8-11 upland peat types; 8 - pine; 9 - pine-cottongrass; 10 - pine-sphagnum; 11 - medium peat; 12-13 transitional peat types; 12 - transitional sedge-sphagnum; 13 - transitional pine; 14 - sand and sandy soil admixture in deposit; 15 - mineral clay sediment and clay soil; 16 - layer change of ash content curve; 17 - layer change of CaO content curve; 18 - curve of layer change of insoluble ash mineral residue content.

The vertical figures show the depth (in meters) and degree of peat decomposition (in %).

The horizontal figures at the top show ash content of peat (in % for absolutely dry material). Those at the bottom show CaO and insoluble mineral residue (in % of total ash content value).

The transitional "Lopotovo" peat deposit has as its upper layer a small stratum (25 cm) of lowland sedge-sphagnum peat with a large amount of fine sand inclusions, then 7 cm of sand-clay sediment. Below this is woody-sphagnum peat, and from a depth of 0. 75 cm, and continuing practically to the bottom, is transitional sedge-sphagnum peat of normal ash content. Characteristic of all three profiles are the abrupt increase in ash content in the upper layer, increase in the amount of insoluble mineral residue in the over-all ash content, and decrease in calcium. In the curves for the remaining layers of the deposit, the principle difference between the ash content of the upper and transitional peat types (preponderance of insoluble mineral residue) and the lowland type (preponderance of CaO) are clearly manifest.

In Table 3, which was compiled by processing materials from more than 50 peat deposits, indices are given for ash CaO, P_2O_5, Fe_2O_3, and insoluble mineral residue in the upper layer[3] and the basic layer of the deposit. As is evident from the table, the ash content of the upper layer in upland and transitional types is from three to four times greater than that in the deep layers and, if the peripheral sections are considered, where the accumulations of mechanical admixtures are greatest, it is from eight to nine times greater. For lowland deposits such relationships are maintained in groups which in the deep layers have no mineral inclusions or traces, especially of lime, vivianite, or siderite. When the latter are present, the increase in ash content of the upper layer may remain less noticeable owing to the high ash content of the deep layers with traces.

The ash content, however, discloses the principle difference between the mentioned mineral deposits in the deep layers which are precipitated from the ground waters as a result of chemical and biogenous sedimentation, and the mineral inclusions of the upper layer precipitated from water or air as the result of mechanical sedimentation. Insoluble mineral residue (50%-80% of total content) characterized by the presence of sand, clay and silt inclusions, is preponderant in the ash content of all

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[3] At a depth of 0-0. 25 and in certain cases, 0. 25-). 50 cm.

Table 3

Characteristics of upper and deep layers of peat deposits[a]

Type of deposit	Ash content	CaO	Fe_2O_3	P_2O_5	Insoluble mineral ash residue	CaO	Insoluble mineral ash residue	Remarks
	% for absolutely dry peat					In % for total amount of ash		
Upland: upper layer	12 11—19	0,42 0,3—0,6	0,24 0,16—0,32	0,26 0,10—0,60	9,0 8—14	3,5 1—6	75 68—75	For 10 deposits, 12 borings
basic horizon	3,3 3—4	0,56 0,5—0,7	0,24 0,15—0,27	0,07 0,06—0,07	1,8 1,5—2,0	17 13—18	55 45—60	
Transitional: upper layer	21 11—60	0,82 0,5—1,3	0,82 0,3—2,6	0,27 0,26—0,40	16 10—55	4,5 1—10	80 73—87	For 7 deposits, 10 borings
basic horizon	6,3 5—7	1,0 0,4—1,3	0,47 0,2—0,6	0,07 0,05—0,20	3,4 2—7	16 10—21	54 53—60	
Lowland, without mineral admix. upper layer	19 13—36	2,5 1,3—3,7	2,6 1—20	0,38 0,20—0,60	10 4—20	13 15—21	53 50—60	For 17 deposits 31 borings
basic horizon	10 5—15	3,6 2,4—5,0	1,07 0,5—1,6	0,14 0,10—0,20	2,0 0,7—5	36 33—46	17 12—21	
Lowland, silted, upper layer	60 50—75	1,5 1—1,6	4,7 2—9	0,50 0,40—0,90	40 38—59	2,5 1—10	66 75—80	For 5 deposits 13 borings
basic horizon	35 28—50	3,1 1,7—3,5	2,7 2—36	0,42 0,15—1,80	22 14—40	9 3—12	63 50—80	
Lowland with lime admixture: upper layer	31 18—45	4,3 1,8—5,4	5,9 1,2—18	1,17 0,2—4,0	11 4—28	14 5—33	35 17—60	For 10 deposits 12 borings
deeper layers without traces	14 10—15	4,8 3,3—6,3	1,16 0,6—3,5	0,18 0,05—0,36	2,3 0,7—5,5	34 26—41	17 10—28	
deeper layers with lime and occasional siderite inclusions	38 30—52	21 10—32	1,1and9,9[b] 0,2—1,5and up to 9,0[b]	0,27 0,1—0,7	0,8 0,7—0,5	55 27—65	2 0,2—10	

[a] In numerator: average values, in denominator: variations

[b] In layers with siderite

Note: Comma represents decimal point.

Table 4

Layer distribution of pH in peat deposit

Peat deposit and type	Depth, m									
	0,25	0,50	0,75	1,0	1,25	1,5	1,75	2,0	2,25	2, 5
	pH in salt extract									
Lopotovo, trans.	4,2	4,1	4,0	3,9	3,9	3,8	3,9	4,0	4,0	4,1
Khutorovskoye, trans.	3,6	3,5	3,4	3,4	—	3,6	—	3,8	—	4,0
Murav'yevo, trans.	4,5	4,2	4,0	4,0	3,8	3,9	3,9	3,9	3,8	3,8
Pyatnitsa, upland	2,8	2,7	2,6	2,6	2,5	2,5	2,6	from 1, 15 m to soil		
Laptevo, upland	2,9	2,7	2,6	2,7		from 1, 15 m to soil				
Tuchkovskoye, lowland	4,2	4,5	4,6	4,8	4,9	5,0	5,0	5.3	5,4	from 2, 25 soil

Note: Comma represents decimal point.

ypes of peat deposits in the upper layer. Es-
ecially characteristic is the high content of nsoluble mineral ash residue in the upper ayers of lowland deposits, in which it does not ormally exceed 20% of the ash total (in the asic peat layer).[4] The calcium content (the asic characteristic for lowland peats) is owered (2, 3). The proportion of calcium in he total ash content is lowered to 15%-20%, vhile in the deep layers CaO comprises 30%-
0% of the entire ash content.

In the sections of silt covered deposits the aO content in the upper layer may amount to %-1.5% for absolutely dry peat, i. e. it ap-
roaches the calcium content in the transition eats. Thus, in the upper layer of the deposit he typical differences of peat are obliterated s evident from the average values (Table 3).

The most characteristic property of the owland type of deposit, especially in dry areas r in sections with variable moisture conditions, s the increased iron content, which sometimes xceeds the calcium content.

Characteristic for all types of an increased hosphorus content in the upper layer of the eposit (2-5 times greater than in the deeper ayers).[5] In many instances the aluminum content is also greater, amounting to 70%-80% of the total sesquioxides in the upper layer of certain lowlands and transitional peat deposits, and 45%-50% in deep layers.

The pH values (In KCl) of the upper layers of the upland and transitional peat deposits, especially in sections subject to surface water flow, are higher than in the layers which directly underlie them where there is maximum acidity.

This is illustrated by the following data for layer-distribution of pH in several small deposits of the Solnechnogorsk area in the Moscow region (Table 4). In lowland deposits maximum acidity may be found in the uppermost layers, as is evident from the same table. These phenomena to a certain extent also obliterate the typical differences in the upper layer.

As a result of changes in the over-all ecological conditions in the vegetation cover of small peat deposits of the upland and transitional types, representatives of great eutrophism appear: Calamagrostis, Carex (rough pistil and bottle shaped), Menyanthes trifoliata, — in upland deposits, Equisetum and Potentilla, — in transitional deposits. In the upper peat layer is found an admixture of peat formative residue of the lowland types (in transitional deposits) or of the transitional types (in the upland deposits).

In transitional peat deposits, which are especially subject to the influence of surface waters, a very thick layer (up to 0.75 m) of lowland peat (according to botanical composition), may overlie the purely transitional peat.

The agricultural value of the changes occurring in the upper layers of the deposit which are influenced by the erosion processes may be considered positive for upland and transitional types of peat deposits. For lowland deposits these changes, evidently, are unlike in different concrete instances.

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[4] Exceptions are silt deposits which have developed lmost exclusively under flood conditions by alluvial aters and transportation of mechanical admixtures.

[5] These data do not pertain to deposits with inclu-
ions of vivianite in which the maximum content of $_2O_5$ (as much as 23%) is typical of layers where here are traces or inclusions of the latter.

The nitrogen content decreases somewhat with the increased ash content of the upper layer and the relative decrease in the amount of organic substances. This is evident from the following data for several lowland types of peat deposits which were studied: the nitrogen content (in percentages for absolutely dry peat) amounts to 1.9%-2.7% in the upper layer, and 2.5%-3.4% in the parent material.

Development of deep erosion has caused the drying up of many peat deposits, especially deposits in ravines and, to a certain extent, those on slopes, and the mineralization of the upper peat layer. We observed such instances in the Moscow, Smolensk, and Bryansk regions.

Pollen analyses were made in several peat deposits. These established that the beginning of the erosion processes' influence on peat deposits is related to the time of late maximum fir, i. e. to the recent period. In many instances the sedimentation layers, or layers of highest ash content were distributed not at the very surface, but at a depth of 10-25 cm. This obviously points to a certain attenuation of the erosion processes in the recent time.

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DISCUSSION

SOME PHILOSOPHIC PROBLEMS IN SOIL SCIENCE

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Pochvovedeniye No. 9, 1958 contained an article by V. V. Ponomareva entitled "The Nature and Factors in Soil Formation," which deals with the most important theoretical problems of soil science. The author criticizes the theory of the factors in soil formation and gives her own interpretation of the causes, conditions, and nature of the soil-forming process. She believes that one must distinguish between the biological nature of the process as the fundamental cause and immediate activating force of soil formation, and the inert material factors, which are the conditions for the development of this process. Only the higher green vegetation, together with microorganisms, may be regarded as a true soil-forming factor; this is only the cause of the genesis and development of the soil. The climate, parent materials, topography, hydrogeological conditions, man's activity, as well as the activity of higher soil animals and other factors, are significant only as conditions for the evolution of the soil-forming process. This distinction between the essence and the conditions of soil formation allows perfect freedom for explaining the reasons for the formation of one soil or another. In conclusion, the author refers to the work of the Kazan soil scientist, R. Rizpolozhenskiy, and points out a certain similarity between his thought and reasoning and her own viewpoint.

Inasmuch as the solution of theoretical problems in soil science, as in all other sciences, depends on the methods used in research, we deem it imperative to review Ponomareva's basic assumptions from this standpoint. Her article, in essence, presents the very real problem of the laws and the nature of soil formation and the conditions for the development of this process. The positive value of her article lies in her posing of the question. Ponomareva's approach to the solution of these problems, however, requires some comment.

One cannot agree completely with the critical part of the article. The author points out two weak features in the Dokuchayev theory of factors in soil formation:

1. The theory of factors does not explain exactly upon what the various factors in soil formation act. The concept that soils are formed by the combined action of the soil-forming factors, at the focus of their mutual action, can hardly be considered sufficiently clear or correct.

2. The various factors cannot be of equal importance or operate in the same direction. The functions of life and their role in one process or another differ so greatly from the part played by inert matter that comparison is unthinkable.

If the meaning of these weaknesses is translated into the language of philosophy, the eclecticism and subjectivism of the theory of factors becomes clear. Were these, however, V. V. Dokuchayev's actual views on soil formation?

The theory of factors has been severely criticized in the field of sociology, for example. According to this antiscientific, eclectic, subjectivistic theory, the development of society is to be explained by the mutual action and interaction of various factors: political, religious, moral, economic, psychological, cultural, natural, etc. Such a theory, as G. V. Plekhanov has accurately observed, merely produces vertigo and explains exactly nothing in the development of society. Only by isolating from among the various aspects of material life of people the leading, determining factor — the means of production of material goods — may one explain the development of society as a regular historical process. This is what historical materialism has accomplished.

It is quite proper to ask the question: do V. V. Dokuchayev's views on soil formation deserve to be reproached for eclecticism, for distorting the actual associations and relationships of nature, or do they correctly and actually reflect these associations and relationships? There can be no two opinions here. The views of the founder of scientific soil science, considering the time in which he lived, accurately reflect the processes in nature.

Dokuchayev has more than once defined soils as independent, natural-historical formations, emphasizing the fact that soil is the result of an exceedingly complex interaction of soil forming factors: parent materials, climate, plant and animal organisms, the age of the land, and the local topography. This is a scientific-philosophic definition. Dokuchayev believed that his definition was "the axiom, the soul, the cornerstone and the most certain guarantee for the future of soil science as a science" (5). The value of this definition consists in the fact that it sharply distinguishes the scientific concept of soils from nonscientific, metaphysical, and mechanistic theories, whose one-sided view reduces soils to chemical, physicochemical, or geological formations. Dokuchayev, of course, understood perfectly that one cannot limit oneself to general indications of mutually interacting factors. He has said that only by studying all the soil-forming factors in detail can one obtain a complete understanding of the soil and control it for purely utilitarian purposes (7).

Dokuchayev himself, as is well known, studied the importance of each factor in soil formation. His own work, as well as the conclusions he drew from the research of other scientists, both in the West and in Russia, inevitably led to a change in the concept of soil and to a more precise definition of the role of particular factors or conditions of soil formation. A comparison of his earlier and later definitions of the concepts of soil and soil formation will easily convince one of this.

Scientific concepts are not fixed or rigid. They are subject to change and development, influenced by man's social and economic practices and the extent of human knowledge. Thus there is nothing astounding in the fact that Dokuchayev moved from one explanation of the function of soil-forming factors to another, more exact one, and correspondingly altered his concept of soil. The dialectics of the growth of knowledge consist of the development of the knowledge of a given phenomenon or process from a recognition of the general associations and interactions of these phenomena to a knowledge of their laws and nature, and then from a first-order knowledge of their nature to a second-order knowledge, etc. In Dokuchayev's works of the later period, parent material, living organisms, and climate become increasingly important as primary factors in soil formation (4, 9). As regards local topography and even climate as soil-forming factors, Dokuchayev makes certain well-known reservations (4, 9).

Chapter III of Dokuchayev's paper on "The Problem of Instituting Faculties of Soil Science and the study of Microorganisms, Especially Bacteriology, in Russian Universities" (7), which was presented with his report to the Agricultural Committee of the Ministry of Agriculture and Government Lands, contains a model program for a course in soil science. Dokuchayev did not personally draw up this program, but in the text he pointed out that he was in complete agreement with it. A section on "Soil Forming Agents" very clearly presents the problem of the relationships between the factors and the conditions of soil formation. Although this section is rather long, we deem it necessary to give it here.

"1. Surface rocks as soil-forming parent material. Importance of the processes and conditions of weathering in soil formation. The concept of soil-forming parent material.

"2. Role of climate in soil formation. Effect of climate on the nature and composition of the soil-forming parent material, on hydrological phenomena and on the organisms living on the surface of the parent material.

"3. Organisms as soil-forming agents. Plant and animal organisms participating in soil formation. Particular significance of organisms in soil genesis.

"4. Local topography and its significance in soil formation... Concept of the soil's age."

It is clear from the foregoing that the soil-forming factors are not all of equal importance. In the strict sense of the word, rocks and live organisms are soil-forming agents. The particular importance of organisms in soil genesis is emphasized, and the role of climate, the importance of topography in soil formation and the age of soils are mentioned.

In his lectures on soil science Dokuchayev clearly distinguishes the primary soil-forming factors — the parent material, climate and organisms — from the conditions of soil formation (9). The elevation, age and relief of the area are only conditions of soil formation, and not actual soil-forming agents. This conclusion allows one to speak of the equivalence of the factors in soil formation in the sense of their being essential to the occurrence of the process, although Dokuchayev himself was of the opposite opinion. Objectively, his research led to a clarification of the nature of soil formation. This must be taken into account in evaluating the Dokuchayevian theory of the factors in soil formation.

Had Ponomareva taken into consideration the evolution of Dokuchayev's own views on the problems of soil formation, she would not have disparaged his broad and deep conception as a position which "can hardly be considered sufficiently clear or correct." By emphasizing the mutual action and the interaction of the soil-forming factors, Dokuchayev indicated the regularity of the transformation of the soil-forming parent material under the action of animal and plant organisms, climate, etc. We therefore cannot agree with Ponomareva's observation that the theory of factors does not tell us what acts on what in the soil-forming process.

The proper attitude to Dokuchayev's legacy of theory, and the problems of succession in the growth of scientific knowledge, are of great importance with regard to principles. As with all scientific theories, Dokuchayev's theory of the factors in soil formation does not pretend, and cannot pretend, to be absolute truth. It can, however, be considered a relative truth in the sense of dialectical materialism. Dokuchayev himself, although he was not a conscious adherent of dialectical materialism, understood this better than many of his contemporaries. "We possess," he said, "a knowledge which is not absolute and definitive, but human and changing. Truths which were once considered permanently established give way to others. The extent of our knowledge constantly increases" (9). The theory of factors (perhaps it is wrong to insist on this terminology) and Dokuchayev's views on soil formation were enriched as soil science developed. They changed their form and became increasingly more precise, while at the same time retaining their rational foundations. Time (the age of the land) has been quite properly separated from the other conditions or factors of soil formation, since it is a basic aspect of the existence of matter, independent of its concrete form. The concept of the equivalence of soil factors has been defined more accurately, and has led to conclusions inconsistent with the essence of soil science as Dokuchayev regarded it.

P. A. Kostychev, and later V. R. Vil'yams, carried out intensive researches on the effect of the biological factor during Dokuchayev's lifetime. The results of this research definitely confirmed the concept of the leading, determining role played by living organisms in soil formation. During the Soviet era, light was thrown on the effect of human activity on soils.

In regard to the second weakness of the theory of factors, we cannot agree with the reasons for which the phenomena of life and inert matter are so sharply differentiated that "a comparison is unthinkable." Life, as a form of existence of matter differs in its specific qualitative nature from the forms of movement inherent in the nature of inorganic matter (mechanical, physical and chemical) and cannot be reduced to these. There can be no doubt of this. From the standpoint of methodology, however, it is wrong to erect an impenetrable barrier between the two forms of existence. The world is one in its material nature. Too great a separation of the phenomena of life from other material phenomena leads to undesirable consequences in concrete research: in biology, to the admission of a special life force; in soil science, to a reevaluation of the part played by the biological factor (10, 12).

Thus the critical part of Ponomareva's article, in our opinion, requires radical revision.

Let us proceed to analyze the author's views on the causes, the nature and the conditions of soil formation.

First of all, it is not clear why Ponomareva uses the method of formal logic in her discussion, basing her argument on the semantic content of the word "factor" instead of ascertaining what Dokuchayev meant in speaking of soil-forming factors. For some reason Ponomareva accepts only one semantic meaning for the word "factor," the motive force which is the cause of some process or phenomenon. She then comes to the conclusion that the word "factor" was used by Dokuchayev in this sense, and overlooks the second meaning of the word, as one of the primary conditions of a process or phenomenon. Dokuchayev did not consider the factors in soil formation as causes alone; he also used such concepts as conditions, elements, variables and agents. He spoke as well of factors in agriculture, mentioning soil as one of them (3, 6).

Thence, proceeding from the assumption that the theory of soil-forming factors does not disclose the direct cause of soil formation, and wishing to determine this, Ponomareva assumes that "the sole and immediate cause of the genesis and development of the soil on this planet is the existence in the biosphere of living, autotrophic organisms — green plants, which cannot live without the mineral elements of the earth's crust and therefore take root in its outermost layer."

We are compelled to disagree with both Ponomareva's premise and with her conclusion. A correct understanding of causality is far from irrelevant to the empirical sciences. Since she does not suspect this, she makes a metaphysical error. The search for an ultimate and immutable prime cause for any phenomenon is untenable, from the methodological standpoint. Only by separating phenomena from their over-all environment and considering them in isolation, especially if they are complex may one speak of cause and effect; in a process of interaction, however, the evolution of cause and effect becomes interchangeable. Dialectical materialism has overcome the limitations of the metaphysical concept of causality, and has shown that the connection between cause and effect is reciprocal. "That which here or now is a cause there or then becomes an effect, and vice versa" (16). Engels considers the true and ultimate cause of all things to be interaction. Our knowledge cannot go beyond this, to a prime cause, without falling into the error of idealism. Recognition of this circumstance, however, obliges one to find the determining, fundamental, regular relationships in the system of reciprocally interacting forces.

Living organisms may appear as both cause and effect in the soil-forming process. V. R. Vil'yams associated soil formation with the development of life on earth. Life arises from elements of inorganic nature and then evolves in accordance with the law of the unity of opposites in the organism and the conditions of its existence. Each new generation, being better adapted to the new conditions, should display new features which are determined by the new conditions of existence.

According to Vil'yams, each plant formation, during the course of its life and growth, changes the conditions of its existence or the soil conditions. In this sense it acts as a cause of change in the soil conditions. New, qualitatively original relationships arise in the water and nutrient regime of the soil along with new conditions of life for the lower and higher plants; and changes in the medium, because of the law of unity of the organism and the conditions of existence, lead to changes in the composition of the plant formation itself. Here the latter appears as an effect of changing soil conditions. The effect of the new plant on the soil will obviously be different. The development of a soil thus occurs dialectically: in the general interaction, causes and effects are constantly interchanged.

The second part of Ponomareva's conception, particularly the idea that plants take root in the uppermost layer of the earth's crust because they cannot exist without the mineral elements in it, is annacurate from the scientific standpoint, as it leads to the assumption of a purpose in nature.

In our opinion it is impossible to determine the essence of soil formation without taking into account the specific character of soil study as a science. It is not our purpose here to examine the subject of soil science, but merely to make some general observations. To recognize that soil science studies the relationship between animate and inanimate nature, between the movements of matter inherent in inorganic nature and in biological forms, that the object of study in soil science is the soil as an independent, natural-historical entity with its own specific-qualitative character which differs from those of other entities in nature, and that only through a knowledge of the laws governing the development of soils is it possible to control soil fertility, is to pose the question of the essence of soil formation. These propositions are not subjective or arbitrary. They have an objective basis, and modern scientific soil science is founded on them.

Essence and law are concepts of a single order and a single stage. A law expresses the essential, internal associations and relationships between phenomena or processes. Processes or phenomena which are associated by a deep, inherent relationship, demand certain specific conditions for their realization. If a law is the essential relationship between two phenomena, there are two sides to its action, one of which is predominant. Every law expresses the unity of opposites.

A complex process cannot be reduced to the function of a single fundamental law, but represents combinations of laws.

There are contradictions in Ponomareva's treatment of the problem of the essence. To begin with, it has been said that the essence of soil formation is a two-sided process of the biological utilization and transformation of the upper layer of the earth's crust; the author, however, ignores the essential relationships between living organisms and soil-forming parent material, and thus attributes a passive role to the latter. This is the role which is transformed by the higher and lower plants through their vital activity, and which she considers to be a condition, while she specifies living organisms as the direct motive force in soil formation.

Thus, one of the essential aspects of the relationship (not the primary one) is reduced to a condition of the process. When the problem is solved in this manner, the concept of soil as an independent, natural-historical entity disappears, and soil science becomes an auxiliary branch of biology. Such attempts to separate the biological essence of soil formation from the conditions of the process tend to lead away from a correct understanding of the subject of soil science. Ponomareva's suggested definition of the essence of soil formation, clothed in the trappings of a metaphysical cause-effect relationship, seems to be farhter from the truth than Vil'yams' definition of the essence of soil formation as a synthesis and decomposition of organic matter, which presupposes a dialectical contradictory interaction between the biological and geological cycles of matter in nature, not to mention the definitions by other soil scientists which have recently appeared in Pochvovedeniye.

Ponomareva notes that the agricultural activity of man is a means of changing the conditions, and consequently of controlling the soil-forming process, but not its essence, which is inseparably linked to the vital activities of the organisms in the soil. In another context she states that the essence of the soil-forming process cannot be seen if it is separated from the material conditions surrounding it, and is thus a function of the latter. The question arises as to why the agricultural activity of man is able to change only the conditions, but not the essence of soil formation. Are not living organisms affected by man's activity? The essence of soil formation does, in fact, depend upon changes in the conditions, and in this respect cannot remain unaltered.

Ponomareva supposes that divorcing the concept of the biological essence of soil formation from that of the conditions of this process gives complete freedom in explaining the causes for the formation of one soil or another, whereas the "theory of factors" limits one to the arbitrary and not always possible task of finding the dominant role of the biological factor in all cases of soil formation, as though this would necessarily eclipse all other factors. There is some doubt that one can attain "complete freedom in explaining the causes for the formation of one soil or another" on the basis of this suggested concept. Soil formation is an extremely intricate complex of opposite processes. True knowledge consists in knowing the oppositions in a given phenomenon or process; simplification for convenience in understanding is not always justified.

In the history of soil science there have been not only underestimations of the biological factor in soil formation, but also conceptions which have overestimated this factor, although to a lesser degree. Such views were expressed by the Kazan scientists Korzhinskiy and Rizpolozhenskiy (10, 12). Korzhinskiy, for example, maintained that the distribution of soil groups depended neither on the climate nor on the substratum on which plants live, nor on the topography, but only on the types of vegetation and the interchanges between them; the interchange between plant formations he attributed to the struggle for existence (10). Both Korzhinskiy and Rizpolozhenskiy drew a sharp distinction between the animate and the inanimate, and saw the essence of life in an activity which Korzhinskiy called vital energy.

Rizpolozhenskiy's views (12) bore the imprint of teleology (the recognition of a purpose in nature). It is worth nothing that N. M. Sibirtsev, in a critique of Rizpolozhenskiy's views on soil, pointed out a "striking tendency to deviate toward excessive metaphysics, which is always undesirable in the realm of natural science." He also stressed the fact that there is not the slightest need to give the relationship between soils (or soil-forming parent material) and organisms any metaphysical tinge, or to see in this a "tendency" on the part of the organized world to seize the non-organized in its responsibility for "future generations" and "in the interests of the development of life" (13).

For these reasons the generalizing theoretical synthesis of Rizpolozhenskiy and Korzhinskiy must be approached critically, without denying the value of their concrete research.

Ponomareva's article provides no basis for a comparison of her views with those of Korzhinskiy and Rizpolozhenskiy. We believe, however, that — to judge by its content — she overrates the biological factor in soil formation. Ponomareva reveals a tendency to underestimate the importance of dialectical materialism for the natural sciences.

In making his theoretical generalizations and inferences, the naturalist must be guided by a philosophy; he cannot avoid dealing with such general concepts and categories as causality, law, essence, form and content, etc. If science is divorced from the philosophy of dialectical materialism, natural scientists will blindly follow a path of complicated and contradictory knowledge, erring in theoretical reasoning and being hampered in their attempts to grasp objective truth. Without taking the place of individual knowledge and without providing ready-made solutions for concrete problems in any of the sciences, the philosophy of dialectical materialism arms scientists with the correct theory and method of acquiring knowledge, and supplies them with a guiding ideology.

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THE PROBLEM OF SOIL CLASSICATION IN THE EASTERN PART OF THE GREAT CAUCASUS (AZERBAYDZHANIAN SSR)

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Cultivation of new lands, rational use of land and increasing fertility in eroded, salinized, waterlogged, etc. lands all require precise calculation, correct nomenclature, and stable classification.

Important in this respect is the report given by I. P. Gerasimov on "Scientific basis for a systematic classification of soils,"[1] at the conference of soil scientists on April 20-26, 1954. It was pointed out in this report that in order to create a standard nomenclature and stable classification it is essential to have a concrete understanding of "genetic soil groups." To obtain this objective, soil characteristics must be found; then it will be possible to define accurately the limitations of this understanding, . e. of genetic groups. According to Gerasimov, uniformity of soil structure and of morphological profile should be an important characteristic. A soil classification of the mountain regions of the Caucasus, especially of the Azerbaydzhanian SSR, was made by Zakharov.[2] During the past several years, however, several of these soil nomenclatures have fallen nto disuse or have been replaced by others. The irregularities resulting from this confused classification make it difficult to carry on research and complicate any use of materials by planning organizations.

In the Union's plans and proposals for soil classification very little space is devoted to soils of the mountain regions. Over a perod of years we have investigated the soils n the eastern part of the Great Caucasus, nd have compiled the following systematic ist of soils.

A. Alpine Zone

1. Mountain-meadow primitive, (primarily undeveloped soils of the southern slopes) on shale and sandy parent materials and conglomerates, under mountain xerophytes and feathery vegetation.

2. Mountain-meadow peats, (typical deep, weak sod-peats), locally, waterlogged peats under mesophytes and alpine meadows.

3. Mountain-meadow sods (deep, primarily on northern exposures; shallow, skeletal and slightly sod on southern exposures) on Jurassic shales, limestones, conglomerates, under Alpine meadows.

B. Sub-Alpine Zone

4. Mountain-meadow-steppe chernozem-like (typical deep, strongly humified, leached, low in humus, shallow rooted) on quartzitic, schistose and carbonaceous rocks under mountain-steppe vegetation, including Festuca sulcata, Stipa, (under comparatively arid climatic conditions).

5. Mountain-meadow-steppe cultivated, or reconverted (shallow, developed primarily on southern exposures and in mountain valleys) on various shales, sandy and clay parent materials, long-cultivated.

6. Mountain-meadow-steppe light-grey (whitish in places) strongly eroded on carbonaceous clays and marl limestones under mountain xerophytes.

7. Humus-carbonaceous (primarily shallow, clay,) on carbonaceous parent materials, under low mountain undergrowth, and under creeping juniper in places.

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[1] Pochvovedeniye No. 8 1954.

[2] S.A. Zakharov. Soil formation factors and soils f Azerbaydzhan. Materials for division into regions f the Azerbaydzhanian SSR. Vol. 2, No. 1, p. 150, Baku, 1927.

C. Mountain-Forest Zone

8. Brown mountain-forest (dark, light clay loam, skeletal, slightly podzolized in patches) on schistose and sandy parent materials under beech and mixed forest.

9. Cinnamon brown mountain-forest (deep, shallow, skeletal) on clay carbonaceous parent materials under oak-hornbeam forests and sparse Sabina.

10. Cinnamon brown steppe (deep, shallow, skeletal) on clay carbonaceous parent materials and conglomerates, long cultivated, under grain and orchard crops.

11. Grey-cinnamon brown (grey chestnut) (shallow, skeletal, carbonaceous) primarily on conglomerates, under Paliurus undergrowth, cultivated in places.

D. Mountain-Steppe Zone

12. Chernozems, ordinary mountain and leached clay loam on sand and limestone debris under mountain-steppe grasses.

13. Heavily mixed chernozems (post-forest in places) clay on carbonaceous clays under grasses and herbaceous growth. Probably under dry forest in the past.

14. Dark chestnut and chestnut (shallow and deep) heavy fine clays and clays, on carbonaceous, and in places gypseous clay, under steppe vegetation and Artemisia.

15. Light chestnut (deep and shallow), in places solonetz-like clays on gypseous clay under xerophytes, primarily Artemesia.

E. Semi-Arid and Partially Mountain Semi-Arid Zone

16. Brown (dark and light solonetz-like, solonchak-like in places, clay) on gypseous clay under ephemeral plants.

17. Grey-brown heavily eroded clay (30%-40% of clay parent material denuded) on carbonaceous clays under low undergrowth.

18. Grey brown (skeletal detrital, undeveloped) on limestone, carbonaceous clay and conglomerates under xerophytes.

F. Lowland Zone of Alluvial and Proluvial Deposits

19. Meadow alluvial (clay-clay materials) on sand-gravel deposits.

20. Meadow-bog (clay-clay materials) on sand-clay deposits.

21. Meadow-forest (grey lowland-forest) and tugay forest (deep, shallow) fine clays and clay loams on alluvial-proluvial deposits under tugay forest.

22. Sandy gravel (alluvial fan soil) on deep gravel.

Others

23. Outcrops of hard and porous rocks.

24. Seaside sandhills and dunes.

It is impossible to characterize all the soils. We shall consider only several basic groups and some questionable names that are often open to discussion.

An observation of the mountain-meadow soils and their individual subgroups points to the fact that as a genetic group they differ greatly from the lowland meadow soils by such characteristics as color, structure, profile structure, and physico-mechanical properties. The group differences within the range of a given group characterize the soils from the standpoint of productivity.

The mountain-meadow primitive soils occur on the upper part of the southern slopes and, to a certain extent, on the southeastern exposures of the northern slopes. Continuous isolation, lack of moisture, xerophytes (high-mountain Festula sulcata, Satureia hortensis, and other mountain xerophytes) impede the accumulation of organic substances. The soil cover is secured by a system of plant roots. In the high mountainous section heavy growths of mountain Festuca sulcata, lichen, and other feathery plants, e. g. Astragalus, Draba, are the only representatives of the plant kingdom. The development of genetic horizons here is a very rare phenomenon. In the majority of cases the A horizon overlies the parent material. Occasionally the southern slopes will be found covered with juniper which stands on the parent material; between the junipers cattle trails can be seen. In such cases even the A horizon is not formed.

There are other types of primitive mountain-meadow soils which are distributed on the lower, gentle slopes. Here the fine earth fraction is thicker, and all genetic horizons are clearly distinguished. In individual instances the soil mass is used for dry land framing, nevertheless the soil skeleton, lack of humus, and xerophytic vegetation are still evident. The sod layer of primitive mountain-meadow soils is not expressed as on the northern, gentle slopes. Such characteristics make it necessary to separate these soils into an independent subgroup of mountain-meadow soils.

The primitive mountain-meadow soils, found in the Caucasus, are probably also found on the southern, xerophytic slopes of the Central Asian mountain ranges.

The mountain-meadow peat soils also differ from the meadow and peat soil types of the North. The peat formation process takes place where there are rich stands of grass, abundant moisture, and comparatively low temperatures.

In the high mountain regions of the Great Caucasus we have observed two types of peat mountain-meadow soil. The first was formed on the gentle northern slopes of the high mountain section, and on a watershed plateau under rich Alpine meadow vegetation; it contained a thick humus horizon. In the upper layer the half-decomposed residue were so interwoven that a slab could be removed with a knife. These highly composted soils contain up to 30% humus and have a low bulk density. In his time, S. A. Zakharov called them soft peat soils.[3]

Another type of mountain-meadow peat soils is formed as individual patches in the high mountain part of the northern slopes, at the discharge of mountain streams or in the zone where glacial and snowmelt waters accumulate. These soils suggest formations of the bog type. On the surface there is formed a peaty layer, distinguishing them readily from the mountain-meadow soft peat soils. Vegetation is mostly mesophytic, moisture is abundant, and reaction is acid.

The mountain-meadow sod soils are one of the widespread subgroups of the mountain-meadow group. Sod soils are found on all slope exposures with the exception of the steep northern slopes, where they are displaced by primitive mountain-meadow soils. They are greatly leached and their color varies from light cinnamon brown to a bright pale yellow. Here the grass stands are higher, and the root system is interwoven in the upper horizon and forms sod. Formation conditions evidently favor intensive decomposition, mineralization, and leaching.

The mountain-meadow-steppe chernozem-like soils are found in large areas above the mountain-forest zone. The climatic characteristics alone indicate that these soils differ greatly from the mountain-meadow soils: (annual precipitation 370-590 mm, temperature 8. 4-4. 7° C, evaporation 550 mm). Several of these soil types have a thickness of 80-90 cm. In strongly humified types in the upper horizon the humus content is 12%-15%. In leached types the humus content amounts to 5%-7%. They have a good structure (granular and finely-granular) and are occasionally interwoven as the nodules of grass roots.

The cultivated meadow-steppe soils are frequently the subject of discussion. Sometimes we call them continuously cultivated soils. Grains, grain-legumes, and potatoes have been raised on these soils for years; this continuous cultivation has changed the soil structure and other morphological characteristics of the plow layer. In most cases the humus content does not exceed 3%-4% in the upper, and 1%-1. 5% in the sub-plow layer horizons. Reaction is usually neutral (pH 6. 9-7. 2) and in slightly leached soil (pH 7. 4-7. 9).

The mountain-meadow-steppe light-grey soils are the most characteristic for the sub-alpine zone of the Great Caucasus. These soils were formed primarily on marl limestones and clays of the chalk age and have a definite lithogenous character. Poor development of the plant cover causes the humus content to be very low (not more than 2%-2. 5% in the upper horizon, and below that as little as 1. 5%). Their color is light grey, occasionally whitish. It is difficult to determine the limits of the humus horizon. The entire soil profile is carbonaceous ($CaCO_3$ from 10%-12% to 40%-50%).

The humus-carbonaceous soils are found in small patches in the sub-alpine zone on a seam of chernozem-type soil and they descend to the forest zone. We have also observed these soils in the mountain-steppe zone. They are formed primarily under low underbrush with mixed grassy vegetation. They are very shallow (18-22 cm) with an abrupt transition to carbonaceous rock. The entire profile effervesces from the surface.

The brown mountain-forest soils occupy the upper and middle part of the moist and shady areas of the mountain-forest zone of the Great Caucasus. As a rule they have a clearly expressed profile. They are characterized by the presence of forest litter (2-5 cm) of nut-like structure, streaks of humus, and iron deposits in the C horizon. Reaction is acid (pH 4-6. 5), the humus content is usually 3%-4% in the upper horizon (without litter), decreasing abruptly with depth.

The cinnamon brown mountain-forest soils occupy the greatest area in the mountain-forest zone (primarily the lower part of both slopes), the eastern border of the main range, and individual areas of the steppe plateau where the climate is comparatively dry. They are characterized by great thickness of the soil profile (up to 130-140 cm), a considerable humus content (from 4%-5% to 6%-7% in the upper, and 2%-2. 5% in the lower horizons), a neutral or slightly leached reaction (pH 7.2-7.8), base saturation (35-45 meq), and high clay content (particles <0.01 mm in diameter comprise 50%-60% and more). No movement of silica or loss of adsorbed cations is evident.

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[3] S. A. Zakharov. Soils of the mountain regions of the USSR. Pochvovedeniye, No. 6, 1937.

The steppe-cinnamon brown soils have been formed as a result of man's activity in cutting the forests in order to use the land for agriculture. As the forests were cut, mountain-meadow soils were formed in the upper boundaries of the forest zone, i.e. the meadow process took place. In the lower section bordering the steppe zone the steppe process took place. Certain forest characteristics are still present in these soils: nut-like structure, and coloring of the lower horizons. They are similar in chemistry and texture to the mountain-steppe soils. This is the result of continuously cultivating these soils.

The grey-cinnamon (grey chestnut) soils are transitional subgroups and are found between the mountain-forest and the mountain-steppe zones. They occasionally penetrate deep into the steppe zone in isolated belts and are characterized by undergrowth cover (primarily shiblyak with mixtures of grass), shallowness, large humus content in the A horizon (up to 6%-7%), and an abrupt transition to the underlying horizon. The entire profile is carbonaceous, with good structure, which is probably the result of a large amount of exchangeable calcium in its composition (nearly 90% of the adsorption capacity) and the small content of easily-soluble salts. In the eastern section of the Great Caucasus, between the mountain-meadow and semi-arid zones, the mountain-steppe chernozems (ordinary, leached, and post-forest chernozem group), and the chestnuts (dark, ordinary, and light) are found.

The area occupied by chernozems in the region of the Great Caucasus is not extensive. They cover the highland section of the steppe plateau (at an elevation of 700 m), and the Shemakhin upland (at an elevation of 800-900 m), which have a mean annual precipitation of 500 mm and a temperature of 11-12° C.

The ordinary chernozems are characterized by a normal profile, thick humus horizon containing 6%-7% humus, granular structure, saturated adsorbed cations, and neutral reaction.

The leached chernozems are very light in the upper horizon. Humus content is 5%-6%, shallow profile. The sub-plow layer is darker and thicker than the upper horizon.

The chernozem-like soils are mostly found on a border of the forest zone; thus many investigators have called them "post-forest" chernozem type soils. Characteristic of the forest are the following trees: oak, wild olive — listnaya grusha (Pyrus salicfolia), Pistacia mutica. The most outstanding characteristic of forest soils, nut-like structure, is observed rarely, and the soils are similar to modern steppe soil masses.

The chernozem-like soils are characterized by a deep profile (up to 120-150 cm, the A_1 and A_2 horizons reaching 80-90 cm), indistinct transition, and by deeply buried horizons in places; evidence of ancient cultivation. The structure in the upper horizon is granular-blocky, with depth it becomes large blocky, compact structure. The humus content is from 5%-7%. No carbonates are found to the depth of a meter. The entire profile (<0.01 mm diameter particles, 75%-85%) has a uniform clay content, saturation by adsorbed bases is approximately 40 meq, and there are very few easily-soluble salts.

The chestnut soils are the most extensive group of the mountain-steppe zone and are found from 400 to 700-800 m above sea level. In certain instances they descend as low as 200 m.

The dark chestnut soils are characterized by a normal profile (upper $A_1 + A_2$ is 50-60 cm), humus content is 3.5%-4.5%, base saturation is 30-35 meq, slightly alkali or neutral reaction, heavy clay content, and very compact structure beginning with the upper A_2. In the sub-plow horizon the <0.01 mm diameter particles amount to more than 80%.

The light chestnut soils differ from the preceeding by a shallow profile, light color, negligible humus content (2.5%-3.5%), carbonates in the entire profile, and strong alkalization. Owing to the presence of sodium in the adsorption bases, the soil becomes sticky when moist. When dry it becomes cloddy, and when broken up it crumbles. On slopes the light chestnut soils have an eroded, shallow, and in places, broken profile.

The semi-arid zone covers a considerable area and borders the eastern terminal of the Great Caucasus on the southeast, east, and northeast. It is characterized by lack of moisture. Brown soils and sierozems are usually found in the semi-arid zone of the Azerbaydzhanian SSR. Lately, however, the brown soils have disappeared from many soil maps. Some of them have been grouped with the grey-brown soils, others have been reclassified as light cinnamon brown soils. We should consider it inopportune to question the existence of brown soils as a transitional group from the mountain-steppe chestnuts to the sierozems of the semi-arid regions.

The brown soils occupy a belt between the light chestnuts and the sierozems. They are concentrated in a comparatively high section of elief in the semi-arid zone. Precipitation here loes not exceed 200-250 mm, and falls mostly luring the fall and winter seasons (Kobestan nd the Apsheron peninsula). The relief is loping and hilly, with gullies. The soil is hallow, (A+B not exceeding 10-15 cm), the tructure of the upper horizon (1-5 cm) is hin, platy and porous. The humus content is . 5%-2. 5%. Below 10-15 cm white-specks are ound. The entire profile is solonetz-like and olonchak-like. In the upper horizon more han 40%-50% of the adsorption cations are Mg and Na. The easily-soluble salts are concentrated in the sub-plow horizon and in the econd half-meter.

The grey-brown soils are distinguished by whitish-brown color, a low humus content (1%-5%); they are solonetz-like and solonchak-like. In the valleys they are dispersed, and on slopes — skeletal. Coarse, skeletal, detrital variations of the brown soils are found on the steep slopes. These soils are undeveloped and contain little humus.

In the lowlands bordering the region of the Great Caucasus are found sierozems which have long been cultivated. These are on alluvial-proluvial deposits and have been greatly changed. In the lowlands many alluvial-meadow, meadow-bog, tugay-forest, meadow-forest, and other soils are found which are young formations. We shall not consider these at present.

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THE USE OF SMALL APPLICATIONS OF MELIORATIVE SUBSTANCES ON SOLONETZ AND SOLONETZ-LIKE SOILS OF THE GREAT HUNGARIAN PLAIN

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The improvement of solonetz soils is a very important problem, not only in Hungary, but wherever this soil group occurs. For more than a century-and-a half Hungarian specialists have sought means to improve these soils and have developed several methods of improvement. Arany's monograph describes these methods (3).

As known, solonetz soils are improved by substances containing calcium. The effectiveness of these substances is explained by ion exchange; as a result the Na ions of the soil colloid exchange with the Ca ions. Thus, physical, chemical, physicochemical, and biological properties of solonetz and solonetz-like soils are improved. Gypsum and calcium carbonate are used as meliorative substances, but in Hungary industrial waste products are often used as well. Some of these are lignite, slag, etc. Many contain large amounts of sulfur which has a well known positive effect on solonetz soils. An old Hungarian method is the "digozas" which consists in the upper layer being covered and mixed with either marl or nonalkali soil horizons containing calcium carbonate. This method was introduced by S. Tessedik who was the first to use it on solonetz soils near the city of Szarvas. As already mentioned, the improvement of solonetz soils is based on the principle of ion exchange and necessitates the use of large amounts of material. This makes it expensive. During the past few years several specialists have worked on cheaper agricultural methods. Several methods are based on deep plowing, in order to turn the lower soil layers into the plow layer; the chemical improvement is physical and mechanical. This results because plowing breaks up the solonetz B_1 horizon which is the cause of the negative characteristics of these soils. Antipov-Karatayev, Pak, and others (1) have successfully used this method in the USSR, and Szentannai (7) and Prettenhoffer (4) have had success with it in Hungary. Another method is the use of small applications of meliorative substances.

In the Ukraine, for example, Grinchenko (2) and others have made small applications of gypsum (2-6 cntr/ha) in powdered form. Experiments with small applications on sugar beets and other crops produced good results.

At present there is no complete explanation of the mechanics involved here. In special literature there are indications that the meliorative substances do not act only as ion exchangeable material, but they also improve calcium nutrition and thus improve the physiological processes in plants. Russell (5) writes in detail concerning this. In Hungary there is also literature on this (6). The possibilities of using meliorative substances are limited. In the worst kinds of solonetz soils, crust solonetz, where the A horizon is frequently absent altogether, this method is useless. We made several experiments to ascertain the possibilities of employing this method on medium and deep solonetz and solonetz meadow soils. In Hungary the digozas and liming methods are used on this soil type.

Description of Meliorative Substances Used

On the basis of data concerning widely-used substances, we selected a mixture of gypsum and defecation slime from sugar refineries (4). This was used in the form of granules. Granulation was performed by appropriate equipment. Granulate size was 2-5 mm in diameter. No technical difficulties were encountered during granule preparation as the defecation slime from sugar refineries contains organic substances sufficient to make the granules cohere.

The purpose of granulating was to facilitate placing the substance near the root systems of the young plants. The granules were sown in rows together with the seeds. Chemical analyse were made, the results of which are given below, to ascertain the content and components of the granules.

Chemical Content of the Granules:

Gypsum. Moisture 2.20%. Ca 25.98%, SO_4 58.34%.

Defecation slime. Moisture 45.89%. CO_2 (Sheibler) 43.80%; Insoluble residue in 10% HCl 2.58%; Organic substance 10.96%; Ca 33.00%; Mg 0.77%; N 0.52%; P_2O_5 1.10% (per dry substance).

Water extract from granules (at room temperature): Ca 2.06% and SO_4 4.62%; at boiling point 3.41% and 5.97% correspondingly; Acetate buffer with pH = 5.0%, 9.02% and 19.46%; buffer with pH = 6, 9.04% and 17.36% buffer with pH = 7, 0.17% and 4.85%; Buffer with pH = 8, Ca 0.15% and SO_4 5.15%.

Water extract from pulverized granules (at room temperature): Ca 3.26% and SO_4 7.87%; at boiling point 5.66% and 9.62% correspondingly; Acetate buffer with pH = 5, 14.03% and 20.02%; buffer with pH = 6, 12.52% and 22.27%; buffer with pH = 7, 0.70 and 13.22%; buffer with pH = 8, Ca 0.45% and SO_4 13.67%. In pulverized granules CO_2 (Sheibler) amounted to 17.60%.

These data show that when pH = 6, the material in the granules dissolves sufficiently well. It may be assumed that the same process occurs in the soil; the upper soil horizon in which the experiments were carried out has a pH of approximately 6.0. Hungarian soil improvers call these soils "acid solonetz" or carbonate-free saline soils.

Description of Experimental Fields and Results Obtained

Experiments were made on the Great Hungarian Plain at the following places: Kunszenmarton, Hodmezevasarhei, (Nadsziget), Beszensög, Karcag. Analytical data for these soils are given in Tables 1, 2, 3, 4. From the water extract analysis (Table 1) it may be supposed that the salt content in the soil is unusually great. Salinization of the lower horizons of these soils is sulphate and large amounts of gypsum are frequently accumulated. This saline profile is characteristic of the solonetz and solonetzic soils of the Great Hungarian Plain. Exchangeable cations and the adsorption capacity of these soils were studied. Data are given in Table 2.

From these data it may be concluded that a high content of the Na ions was observed in the composition of the adsorption cations in all these soils. In the soil from Kunszenmarton, for example, this value exceeds 30% in the B horizon. Kunszenmarton and Beszensög, according to the analysis data, and also from the morphological standpoint, concern solonetz soils, while Karcag and Nadsziget concern solonetz-like meadow soils.

Table 3 gives data on the content of humus and nutritive substances in the soils studied. It is evident from the table that these substances as well as the C:N ratio are characteristic of deep and medium solonetz and solonetz-like soils of the Great Hungarian Plain.

Experiments and evaluation of results were made as follows:

Kunszenmarton. Experiments were made on 1.5 ha of land, on 12 plots, replicated four times, with three treatments. First treatment: 530 kg of granulate per ha, second treatment: 1060 kg per ha, third treatment: control.

After the soil had been worked in the spring of 1956, 178 kg/ha of superphosphate, and 70 kg/ha of ammonium nitrate were applied before planting. The meliorative substance was applied prior to the seeding with a combination drill, hence it was sown below the seeds. The experimental crop was sugar beets. During the vegetation period the best plant development was observed in the plots to which 1060 kg of meliorative substance had been applied. Weather conditions in this region during 1956 were very unfavorable for crops, and this explains the low sugar beet yields in our experiments and throughout the entire region. A considerable difference was observed, however, between the treated and the nontreated plots. Data for this are given in Table 4.

Chemical analysis of the beets as well as yield calculation was made; the results are given in Table 5.

From Table 4 it is evident that where 530 kg of meliorative substance was applied, there was a yield increase of 10%; this value, however, cannot be accepted as significant. Where 1060 kg had been applied, there was a yield increase of more than 25%. This value is mathematically significant. From Table 5 it may be concluded that the sugar content of the beets was higher in the plots with meliorative substance applications than in the control plots. The difference is highly significant.

In the fall of 1956 winter wheat was sown in the Kunszenmarton experimental field to determine the residual effect of our experiment. As evident from the data of Table 4 no difference was observed in 1956 between the meliorative and control plots. It should be mentioned that the year 1957, as compared with 1956, was very wet and the good yields of winter crops were attributed to this. In these soil-melioration experiments no noticeable differences were obtained anywhere.

Table 1

Analysis of water extracts from soils studied

Profile No. and location	Depth, cm	Dry residue, %	Ignited residue, %	Water soluble humus, %	Alkalinity			Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	$Na^+ + K^+$
					from Na HCO_3	from Ca $(HCO_3)_2$	total in HCO_3					
					percentages meq							meq
Kunszen-marton	0–20	0,088	0,0052	0,009	0,018 0,303	0,001 0,018	0,019 0,321	0,001 0,039	0,013 0,272	0,001 0,019	0,001 0,049	0,802
I	20–40	0,206	0,152	0,009	0,023 0,384	0,007 0,123	0,031 0,506	0,001 0,039	0,024 0,512	0,001 0,049	0,001 0,057	0,948
	40–60	0,217	0,159	0,008	0,062 1,013	0,003 0,051	0,065 1,064	0,001 0,048	0,075 0,574	0,001 0,059	0,001 0,120	0,754
	60–80	2,021	2,014	0,007	0,006 0,100	0,008 0,142	0,015 0,242	0,003 0,098	1,242 26,857	0,094 4,715	0,093 7,689	8,702
	80–100	0,540	0,500	—	0,016 0,262	0,023 0,385	0,039 0,647	0,003 0,079	0,331 6,895	0,014 0,723	0,009 0,781	4,560
	100–120	0,213	0,208	—	0,065 1,074	0,004 0,060	0,069 1,134	0,001 0,048	0,069 1,445	0,001 0,074	0,002 0,205	2,583
II	0–20	0,071	0,030	0,008	0,025 0,405	0,005 0,080	0,029 0,485	0,001 0,039	0,006 0,135	0,001 0,039	0,001 0,082	0,641
	20–40	0,117	0,086	0,007	0,029 0,485	0,002 0,041	0,032 0,526	0,001 0,039	0,031 0,649	0,001 0,039	0,071 0,057	1,379
	40–60	2,104	1,843	0,010	0,011 0,182	0,011 0,187	0,022 0,364	0,005 0,158	1,249 26,011	0,110 5,489	0,112 9,210	7,398
	60–80	2,187	1,928	0,007	0,008 0,141	0,007 0,121	0,016 0,262	0,007 0,200	1,218 25,352	0,094 4,715	0,110 9,087	7,524
	80–100	1,939	1,926	—	0,007 0,121	0,007 0,111	0,014 0,233	0,005 0,149	1,101 22,920	0,095 4,740	0,083 6,825	6,437
III	0–20	0,064	0,041	0,007	0,019 0,321	0,002 0,042	0,022 0,364	0,002 0,059	0,009 0,195	0,001 0,009	0,001 0,057	0,607
	20–40	0,187	0,133	0,013	0,042 0,688	0,013 0,223	0,031 0,506	0,003 0,079	0,050 1,045	0,001 0,019	0,002 0,189	1,422
	40–60	2,195	1,878	0,010	0,009 0,162	0,009 0,159	0,019 0,321	0,001 0,039	1,157 24,083	0,090 4,491	0,089 6,538	6,224
	60–80	2,224	1,990	0,111	0,009 0,162	0,013 0,221	0,023 0,383	0,002 0,059	1,235 25,719	0,098 4,915	0,083 6,825	6,838
	80–100	0,269	0,231	—	0,073 1,195	0,028 0,465	0,069 0,647	0,001 0,019	0,092 0,882	0,003 0,154	0,002 0,205	1,880
	100–120	0,199	9,134	—	0,076 1,256	0,016 0,264	0,032 0,556	0,001 0,019	0,029 0,601	0,001 0,020	0,002 0,205	1,106
I V	0–20	0,073	0,014	0,010	0,015 0,242	0,007 0,121	0,012 0,206	0,001 0,039	0,008 0,177	0,001 0,019	0,001 0,060	0,259
	20 - 40	0,114	0,086	0,011	0,017 0,283	0,002 0,038	0,019 0,321	0,001 0,019	0,009 0,187	0,001 0,020	0,002 0,205	0,457
	40–60	0,252	0,101	0,011	0,041 0,068	0,025 0,405	0,065 1,074	0,004 0,118	0.028 0,591	0,002 0,144	0,005 0,452	1,262
Nadsziget	0–20	0,154	0,054	0,008	0,075 1,220	0,009 0,148	0,084 1,380	0,014 0,382	0,015 0,308	0,003 0,147	0,004 0,354	1,800
	20–40	0,247	0,194	0,009	0,072 1,180	0,014 0,225	0,086 1,400	0.017 0,472	0,049 1,020	0,003 0,147	0,001 0,041	3,365
	40–60	1,066	0,948	0,007	0,016 0,260	0,025 0,402	0,040 0,660	0,021 0,582	0,613 12,790	0,058 2,842	0,029 2,400	8,091

Note: Comma represents decimal point.

Table 1 Continuation

Profile No. and location	Depth, cm	Dry residue, %	Ignited residue, %	Water soluble humus, %	Alkalinity from Na HCO$_3$	Alkalinity from Ca (HCO$_3$)$_2$	Alkalinity total in HCO$_3$	Cl$^-$	SO$_4^=$	Ca^{++}	Mg^{++}	Na$^+$ + K$^+$
					percentages meq							meq
	60–80	1,195	1,090	0,008	0,016 0,260	0,017 0,280	0,033 0,540	0,027 0,760	0,704 14,660	0,058 2,791	0,042 3,440	10,132
	80–100	0,671	0,535	—	0,047 0,760	0,024 0,398	0,071 1,160	0,035 0,984	0,301 6,260	0,006 0,269	0,007 0,535	8,065
	100–120	0,550	0,502	—	0,067 1,100	0,011 0,182	0,078 1,280	0,042 1,175	0,251 5,420	0,004 0,182	0,003 0,264	7,405
Beszensög I	0–20	0,113	0,053	0,006	0,018 0,295	0,004 0,070	0,022 0,365	0,005 0,140	0,048 0,999	0,003 0,146	0,002 0,181	1,177
	20–40	0,191	0,143	0,012	0,020 0,336	0,005 0,082	0,025 0,418	0,002 0,121	0,061 1,265	0,005 0,244	0,002 0,139	1,421
	40–60	0,318	0,273	0,008	0,026 0,429	0,008 0,133	0,034 0,562	0,006 0,183	0,146 3,046	0,005 0,268	0,002 0,139	3,382
	60–80	2,333	1,999	0,004	0,004 0,074	0,007 0,119	0,012 0,193	0,009 0,274	1,371 28,545	0,184 9,173	0,050 4,142	15,696
	80–100	2,385	2,069	—	0,005 0,085	0,007 0,118	0,012 0,203	0,011 0,303	1,424 29,656	0,195 9,764	0,016 0,332	19,066
	100–120	0,688	0,630	—	0,034 0,567	0,006 0,105	0,041 0,672	0,014 0,405	0,352 7,341	0,009 0,439	0,008 0,682	7,297
	120–140	0,578	0,536	—	0,038 0,636	0,011 0,190	0,050 0,826	0,014 0,406	0,326 6,793	0,006 0,292	0,007 0,576	7,157
II	0–20	0,136	0,097	0,005	0,012 0,203	0,002 0,041	0,015 0,244	0,012 0,346	0,060 1,249	0,014 0,536	0,004 0,320	0,981
	20–40	0,097	0,051	0,009	0,021 0,343	0,001 0,085	0,026 0,428	0,008 0,223	0,018 0,377	0,029 0,146	0,002 0,181	0,900
	40–60	0,177	0,119	0,014	0,026 0,436	0,001 0,002	0,027 0,437	0,007 0,203	0,054 0,120	0,004 0,219	0,002 0,189	1,370
	60–80	0,280	0,225	0,008	0,032 0,529	0,005 0,121	0,039 0,651	0,012 0,345	0,127 2,652	0,006 0,298	0,010 0,863	2,497
	80–100	0,258	1,923	—	0,007 0,121	0,005 0,092	0,013 0,213	0,017 0,507	1,309 27,260	0,237 11,824	0,058 4,827	11,330
	100–120	2,114	1,860	—	0,007 0,111	0,001 0,183	0,018 0,295	0,017 0,497	1,287 26,798	0,216 10,803	0,038 3,166	13,621
	120–140	0,383	0,328	—	0,037 0,616	0,013 0,229	0,051 0,836	0,018 0,526	0,193 4,020	0,014 0,696	0,003 0,251	4,433
Karcag I	0–14	0,125	0,041	0,038	0,019 0,315	0,010 0,169	0,029 0,484	0,005 0,158	0,011 0,225	0,003 0,159	0,002 0,181	0,640
	14–30	0,124	0,041	0,037	0,037 0,610	—	0,037 0,610	0,008 0,219	0,009 0,200	0,002 0,129	0,001 0,123	2,000
	30–45	0,171	0,124	0,032	0,029 0,484	0,007 0,126	0,037 0,610	0,022 0,619	0,018 0,387	0,003 0,135	0,001 0,123	1,948
	50–60	0,323	0,257	0,037	0.023 0,379	0,010 0,167	0,033 0,546	0,051 1,439	0,045 0,950	0,003 0,169	0,002 0,181	3,825
	70–80	2,196	1,841	0,015	0,013 0,210	0,014 0,231	0,027 0,441	0,056 1,577	1,140 23,754	0,026 1,317	0,072 5,921	8,586
	90–105	1,600	1,371	—	0,014 0,231	0,012 0,210	0,027 0,441	0,053 1,498	0,735 15,329	0,019 0,958	0,035 2,919	8,007

Note: Comma represents decimal point.

Table 2

Exchangeable cations and adsorption capacity of soils studied

Profile No. and location	Depth, cm	Ca	Mg	Na + K	Total cations S	Adsorption capacity, t	Ca	Mg	Na + K
		meq/100g					in % of total (S)		
Kunszenmarton I	0—20	13,8	1,7	2,6	18,1	29,9	76,2	9,6	14,2
	20—40	19,7	11,6	7,6	38,9	39,4	50,7	29,8	18,5
II	0—20	14,3	3,5	6,8	24,7	29,2	58,2	14,1	26,7
	20—40	13,5	13,2	12,0	38,6	40,6	34,9	34,1	31,0
III	0—20	21,8	6,6	4,4	28,6	36,7	76,4	23,0	15,6
	20—40	22,2	13,2	6,2	41,6	45,4	53,3	31,8	14,9
IV	0—20	11,1	4,3	4,4	19,7	24,6	56,0	21,6	22,3
	20—40	17,2	13,7	13,1	43,9	45,2	39,2	31,0	29,8
V	0—20	11,6	4,3	5,0	21,0	29,8	55,5	20,6	24,0
	20—40	1,1	18,1	14,8	43,9	45,3	25,2	41,2	34,0
VI	0—20	16,8	3,5	4,4	24,7	31,2	67,8	14,1	18,0
	20—40	22,2	11,4	12,0	45,6	49,2	48,6	25,0	26,3
VII	0—20	13,1	5,1	5,6	23,7	31,2	55,0	21,7	23,5
	20—40	15,5	6,6	12,2	34,3	36,9	45,2	19,2	35,6
	40—60	32,6	6,4	13,3	52,4	48,3	62,3	12,2	25,5
VIII	0—20	13,5	3,9	4,3	21,4	31,2	61,9	18,1	20,0
	20—40	18,5	15,8	13,5	47,7	55,5	38,7	33,1	28,2
IX	0—20	9,5	5,1	2,7	17,3	19,8	54,7	29,8	15,7
	20—40	10,6	1,7	3,8	16,1	22,7	65,7	10,9	23,4
X	0—20	13,9	4,9	5,1	23,9	31,3	58,0	20,6	21,2
	20—40	17,2	12,5	13,8	43,5	46,7	39,5	28,7	36,6
XI	0—20	16,2	12,8	8,5	37,3	36,9	43,4	34,4	22,7
	20—40	10,8	7,9	5,0	23,7	28,4	45,5	33,6	20,9
XII	0—20	10,8	11,4	2,8	25,0	28,4	43,2	45,7	11,1
	20—40	14,8	10,9	5,0	30,6	34,1	48,2	35,4	16,4
	40—60	16,6	12,4	6,7	35,6	38,3	46,5	34,8	18,8
Karcag I	5—10	18,7	6,9	2,5	28,2	26,1	66,3	24,6	9,0
	20—26	15,2	11,6	2,1	28,9	30,6	52,3	40,2	7,3
	43—49	12,5	8,9	4,4	25,8	27,4	48,4	35,5	17,2
Nadsziget I	0—20	10,2	11,2	5,0	26,3	48,2	38,9	42,5	18,6
	20—40	10,2	18,3	9,6	38,1	52,1	26,7	48,3	25,1
	40—60	8,8	21,1	14,1	44,0	54,6	19,9	47,9	31,7
II	0—20	10,7	7,5	2,7	20,9	34,1	51,3	35,8	13,0
	20—40	11,4	15,5	7,1	35,9	43,1	33,6	45,5	20,9
	40—60	11,4	17,9	11,3	40,6	55,8	28,0	44,2	27,9
Beszensög I	0—20	11,0	12,9	2,8	26,9	37,5	40,9	48,2	10,9
	14—30	17,0	25,7	5,1	47,9	53,9	35,5	53,8	10,7
	30—45	15,0	35,6	8,4	59,1	58,9	25,4	60,3	14,3

Table 3

Potassium, phosphorus, nitrogen, and humus content in soils studied

Profile No. and location	Depth, cm	K_2O	P_2O_5	N %	humus %
		meq/100g			
Kunszenmarton I	0—20	27,5	3,00	0,165	3,485
	20—40	19,0	1,00	0,203	3,494
II	0—20	24,0	2,50	0,255	3,306
	20—40	20,0	1,20	0,140	3,201
	40—60	19,5	1,20	—	—
III	0—20	25,5	4,00	0,158	2,673
	20—40	19,5	1,20	0,123	2,804
IV	0—20	24,0	3,80	0,185	3,620
	20—40	15,5	1,00	0,115	2,173
V	0—20	18,0	5,80	0,180	2,108
	20—40	11,0	4,50	0,122	2,496
VI	0—20	15,5	2,80	0,177	2,269
	20—40	9,5	1,00	0,144	2,349
VII	0—20	19,0	2,00	0,179	2,290
	20—40	15,5	1,00	0,132	2,240
	40—60	11,0	1,20		
VIII	0—20	11,0	1,50	0,157	2,359
	20—40	6,5	0,80	0,124	2,347
IX	0—20	15,5	2,50	0,221	2,877
	20—40	11,5	1,00	0,160	2,373
X	0—20	15,5	1,20	0,199	2,860
	20—40	15,5	1,20	0,146	2,482
XI	0—20	11,0	1,80	0,169	2,420
	20—40	11,0	2,00	0,183	2,620

Note: Comma represents decimal point.

Table 3 Continuation

Profile No. and location	Depth, cm	K_2O	P_2O_5	N %	humus %	Profile No. and location	Depth, cm	K_2O	P_2O_5	N %	humus %
		meq/100g						meq/100g			
XII	0—20	19,0	2,20	0,157	2,580	II	0—20	15,44	12,48	0,127	3,776
	20—40	15,5	2,00	0,133	2,633		20—40	7,80	12,48	0,143	2,247
	40 - 60	19,0	2,00				40—60	4,80	14,40	0,088	1,873
Beszensög I	0—20	19,20	14,56	0,122	3,101		60—80	5,68	19,36	—	—
	20—40	11,40	12,48	0,088	2,377						
	40—60	6,00	14,56	0,078	1,619						
	60—80	5,52	19,84	—	—						

Note: Comma represents decimal point.

Table 4

Results of field experiments

Location of experiment and year	Crop	Treatments	Yield	Increase	Relative Yield, %
			cntr/ha		
Kunszenmarton, 1956	Sugar beets	Control	37. 75	—	100
		Granulated 530 kg	39. 24	1. 49	103
		Granulated 1060 kg	44. 82	7. 07	108. 8
Kunszenmarton, 1957	Wheat (after effect)	Control	22. 41	—	100
		Granulated 554 kg	22. 61	0. 20	101. 04
		Granulated 1224 kg	22. 53	0. 12	100. 40
Nadsziget 1957	Corn (cob)	Control	39. 91		100
		Granulated 21 kg	46. 96	7. 05	117. 68
Beszensög 1957	Wheat	Control	26. 94		100
		Granulated 1060 kg	31. 28	4. 34	116. 23
		$(NH_4)_2SO_4$ 234 kg	28. 47	1. 53	105. 67
Karcag, 1957	Wheat	Control	27. 07		100
		Granulated 1060 kg	29. 43	2. 36	108. 71 28. 5

Beszensög. In 1956, experiments like those previously mentioned were made in this territory with winter wheat on 12 plots with four licates. Unlike the experiments at Kunszenmarton, only 1060 kg/ha of meliorative substance was used. In the third treatment 200 kg/ha of ammonium sulphate was applied alone, while the meliorative plots received a certain application of this fertilizer. As can be seen from Table 4, the meliorative plots gave higher yields, not only as compared with the control, but as compared with the plots that received only ammonium sulphate. These increases, however, were below the range of reliability.

Karcag. Experiments were made in the spring

Table 5

Chemical analysis of sugar beets, %

Treatments	Ash	Residual N[a]	Albumin N	Total N	Sugar with 70% moisture
1060 kg/ha granulated	1.93	0.228	0.970	1.198	18.71
530 kg/ha granulated	2.09	0.270	1.076	1.348	18.81
Control	1.475	0.234	1.000	1.236	14.57

[a] Difference between total and albuminous nitrogen (residual)

of 1956 on 2 ha of land, on six plots with two replicates. 1060 kg/ha of granulate was applied and the second treatment was used as a control. As evident from Table 4, the results are very similar to those of Beszensög. Although an increase in yield was obtained, the difference is not significant.

Nadsziget. (Near Hodmezevasarhei). Experiments were made on 1 ha of land with three treatments and three replicates of corn. Before being worked, the ground received 180 kg/ha of superphosphate. Meliorative substance was applied in the corn rows prior to planting. 200 kg/ha of meliorative substance was applied. During the vegetation period the plants developed better on the meliorative plots than on the control ones. From Table 4 it may be seen that applications of meliorative substances in granular form increased yields by almost 18%. This is mathematically significent.

As our experiments show, small applications of granular meliorative substances at planting time produced reliable increases in yields, while in winter wheat, although an effect was observed, it is not significant.

CONCLUSIONS

1. In certain solonetz and solonetz-like soils, characteristic of the Great Hungarian Plain, we used small applications of meliorative substances in the following regions: Kunszenmarton, Nadsziget, Beszensög, and Karcag. According to chemical analysis these soils are deep and medium solonetz. Some are meadow solonetz-like soils.

In the experiments at Kunszenmarton sugar beets were sown in 1956 and winter wheat in 1957. In the experiments at Nadsziget and Karcag, winter wheat was sown in 1957.

The meliorative substance was prepared in the form of a mixture of defecation slime and powdered gypsum by granulation at a ratio of 1:1. Diameter of the granules was 2-5 mm. Five to 10 cntr/ha were applied to the soil at seeding time.

2. In plots where the meliorative substance was applied the plants grew better, and in the case of application at seeding time a reliable yield increase was obtained. Increased yields of grains were not great, although an effect was evident. It must be noted that 1957 climatic conditions did not allow experiments to be made with grains in the Hungarian saline soils as heavy rains fell during the vegetation period and a good yield of winter grains was obtained on saline soils.

3. The use of meliorative substances not only increased yields, but also increased the sugar content of sugar beets by more than 3%.

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THE SOILS OF POLAND AND THEIR CLASSICATION

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In September 1957 a conference on problems of soil classification, systematics and nomenclature was held in the Polish Peoples' Republic. Soil scientists participating in the conference represented five countries: Poland, Czechoslovakia, the German Democratic Republic, Hungary, and the USSR.

The conference consisted of two parts: a discussion of the soil classification of Poland and the countries participating in the conference; and field trips, in which the delegates were introduced to the basic soil groups of Poland. The participants could thus concretely discuss classification problems and also individual problems concerning soil groups that were examined during the field trips.

The purpose of this report is to acquaint Soviet soil scientists with specific problems of the most prevalant soil groups of Poland and with the discussions of the delegates concerning various genetic problems. We shall begin with soils of the podzolic group.

Soils of the podzolic group are formed in Poland primarily on glacial material and contain no, or very little, calcium carbonate. These soils are dominant among the soils of Poland. Within this group the Polish soil scientists distinguish four subgroups; typical podzolic, gleyed podzolic, typical podzols, and gleyed podzols.

According to the soil system of the USSR, the podzolic soils of Poland are similar to the sod-podzolic subgroup, although the former possess several specific peculiarities. These are:

1. In the B_1 horizon, even in broken terrain, there are indications of widespread gleying. This is evidently a result of the heavy atmospheric precipitation in these regions which greatly prolongs the period of anaerobiosis in the B horizon. The B horizon has a marble-like color. Along the root systems (where there is a lighter penetration of water) the color is bluish-grey. On the periphery of these blue streaks the color is rust-brown; between cracks it is brown. Because most of these clay loam podzolic soils bear such traces of gleying, Polish soil scientists consider that they belong to the clay loam podzolic soils and therefore do not name them. They relate only soils with uniform gleying of the horizon to the podzolic gleyed subgroup.

The German soil scientists, on the other hand, distinguish soils with a gleyed marble-like horizon and call them Marmorierte Böden, Pseudogleypodsol, and Podsolpseudogley. They consider these characteristics to be of great importance.

2. The humus horizons of the sod-podzolic soils of Poland contain very little humus under natural conditions (1.5%-2%). According to this characteristic they may be compared only with the sod-podzolic soils of our western regions (the Baltic Republics and the Belorussian SSR). We associate the low humus content with the more favorable regime for microbiological processes of organic substance decomposition.

3. In Poland, the widely distributed, pale yellow, sod-podzolic soils are usually associated with double alluvia (clay loam top underlain by morainic clay loam or sand). They are characterized by a pale yellow color in the A_2 horizon. Often a second, whitish, gleyed horizon is present at the boundary between the two deposits.

In the guide book compiled for the field trips these soils were called podzolic. In our literature they are called "pale yellow podzolic" soils. Different investigators in the USSR explain their genesis in different ways. Some consider the pale yellow podzolic soils to be a transition to the "burozems," others connect their formation with deciduous forest, while still others explain the pale yellow color of the A_2 horizon by a secondary fusion of iron with the soil solutions present where the two soils join. Thus, until lately the status of the pale yellow podzolic soils was not established exactly in the soil systematics of the USSR.

The German soil scientists (as was ascertained during the field trips) relate these soils to a special soil group which they call "lessivé." This refers to soils in which the clay particles are removed from the surface layer into the B horizon and below. Decomposition of the clay minerals, however, does not occur. This can be proved by two methods: first, by detection under a microscope of migration forms of clay in the B horizon (not usually observed in the podzolic soils of the GDR); and second, by the fact that the total clay content in the "lessivé" soil profile is homogenous. The total chemical soil analysis, however, discloses an accumulation of silicic acid in the upper horizons which are joined by clay. In podzolic soils the total composition of clay repeats the picture of the soil analysis as a whole. It seems to us that these are insufficient arguments on which to base the "lessivé" process. In order to distinguish the clay decomposition process from the process of its "total" removal, we think it is absolutely essential to determine the mobile forms of iron and aluminum as well as to study the nature of the clay migration.

Following a discussion of these problems, the conference delegates moved to perform additional research during the next few years on the clarification of migration forms of substances in the soil.

4. The sandy sod-podzolic soils of Poland have as a rule an illuvial humus-iron-like horizon (even when formed in dune relief), and a thick litter (5-7 cm) of well-decomposed leaves. Underneath this there is a clearly-defined humus horizon. Such peculiar profiles of sod-podzolic illuvial humus soils are found in the USSR only in the border regions of the extreme West. Similar soils were observed by us in the sands of Northern France during field trips of the Sixth International Congress of the Soil Science Society. Among the sod-podzolic soils described there are found, under the most xerophytic conditions, individual areas whose soils have practically no humus horizon. Immediately below the litter there is a grey-whiteish A_2 horizon which turns into a light yellow B horizon. These soils are not prevalent, nor are they characteristic of Polish soils.

As a result of our acquaintance with the podzolic soils of Poland and the discussions of field trip participants, we concluded that in view of its peculiar bioclimatic conditions, the territory of Poland represents a special soil province for which the following are characteristic: 1) A very intensive biological cycle which causes a rapid mineralization of organic residue and a negligible accumulation of humus in the soil. 2) A great prevalence of perched gley horizons caused by heavy atmospheric moisture. 3) A high mobility of iron, caused by stable anaerobiosis in the average part of the profile, which may cause the drawing up of iron into the surface layers creating the yellow color of the podzolic horizon and equalization of the $SiO_2 : R_2O_3$ ratio in the clay fraction throughout the profile of these soils.

These specific characteristics in podzolic soils are, in our opinion, sufficient basis for designating them as an independent subgroup of the podzolic soil group.

In addition to the discussion of systematics of the podzolic group, a question was raised concerning systematics of the podzolic bog soils. In Poland these are designated only as subgroups of the podzolic group (gleyed podzols, gleyed podzolic soils).

Soil scientists of the GDR presented the most detailed and clearest division of podzolic and bog podzolic soils. This was in accordance with the character and degree of gleying. According to their system, all soils in which gleying is present are divided into three genetic groups: 1) pseudogley, 2) stagnogley, and 3) gley.

As mentioned previously, pseudogley means gleying which takes place as a result of atmospheric moisture, with no lateral moisture flow from ground water. These soils are temporarily excessively wet. In their profiles, sections of "reduced" and "oxidized" gley are distinguished among the non-gleyed masses. Stagnogley soils are either formed by a certain subflow of surface soil water, associated with a redistribution of precipitation in the microrelief, or are caused by a lack of drainage. Characteristic of the stagnogleys are stable gleying processes, a uniform, perched gley horizon, (not connected with subsoil waters), and "reduced" and "oxidized" gley in the profile, with an absence of a nongleyed mass.

Gley is gleying associated with the ground water. Within each of these groups there are divisions according to depth of the gleyed horizon. In the "gley" group, for example, the following subgroups are distinguished: podsolgley (gleying in the B horizon) and rohumusgley (gleying in the A_2 horizon.) In the podzolic group are distinguished podzol, podzol over gley, and gley podzol. In the first there is no gleying, in the second there are indications of gleying under the C horizon, and in the third there is gleying in the C horizon.

It should be kept in mind that the term "podzol" does not indicate "degree of podzolization," but merely indicates a group.

Rendzinas are very prevalent in Poland. It is generally known that this term, and the soil group connected with it, was first introduced by the Polish soil scientists.

The Polish soil scientists define rendzinas as a group of soils formed on calcium-rich rock. Rendzinas are divided into two large subgroups: calcareous rendzinas on rocks rich in carbonates, and sulfate rendzinas on gypsum rock. Within these two subgroups, depending upon the general configuration of the soil profile (and consequently, upon the conditions under which a given soil is formed), the following soil groups are distinguished: 1) Rendzinas at the beginning stage of development (AC profile), 2) Burozem rendzinas, 3) Chernozem rendzinas,

A further division of the group is based on the characteristics and age of the parent materials (Cretaceous, Jurassic, on pure limestone, on mixed calcareous silicate, etc.).

In Germany, the rendzina group includes soils with an A horizon and an AC profile, but which are developed on thick calcareous rock.

If a soil has an A horizon, an AC profile, but is developed on mixed (calcareous-silica) rock, (loess, marl, ribbon calcareous clay, etc.), it belongs to the pararendzinas (rendzina-like soils), i. e. it corresponds to mixed rendzinas according to the Polish classification system.

If soils have an ABC profile, they are considered respectively as: 1) burozem (chernozem, podzolic) rendzina, 2) burozem (chernozem pdozolic) pararendzina.[1]

Thus, the rendzinas of early development stages are incorporated into one group by both the Polish and the German soil scientists, regardless of their formation conditions.

The soil systematics of the Soviet Union are based on recognition of the soil formation processes uniting with the media conditions from the initial stages of soil development. For this reason the poorly-developed detrital soils of the northern USSR are never incorporated with the stony, poorly-developed soils of the south, even if they are developed on the same kind of rock, including calcareous.

This difference of opinion, which might seem serious from the discussions, results from the fact that Poland is located within two subzones, i. e. natural conditions throughout the entire area are comparatively similar. It is perfectly natural that at different stages of soil development, the nature of the soil-forming rocks is of great importance, and may attenuate the specific characteristics of soil formation that are brought about by negligible changes in bioclimatic conditions. In the posing of this problem the opinions of both the Soviet and Polish soil scientists agreed.

The Polish soil scientists classify burozem and chernozem rendzinas as independent soil groups. The Soviet soil scientists have a slightly different approach to the problem. Soils developed on calcareous rock are classified as an independent group only when large amounts of calcium carbonates or magnesium carbonate greatly alter the trend of the soil formation process resulting from a given combination of bioclimatic factors of a given zone (e. g. sod-calcareous soils among podzolic soils). Where this is not the case, the specific characteristics of soils formed on limestone rocks are placed in the genus category (e. g. residual-calcareous shallow detrital chernozem). However, the disagreement on this question between the Soviet and Polish soil systematics actually amounts to a different taxonomic evaluation of the effect of rocks on soil formation. The character and the divisibility of actual soil divisions concur.

In the Soviet Union the sod-carbonate soil group, i. e. soils formed on calcareous rocks in the podzolic soil zone, is not limited to poorly-developed detrital variants, but also includes soils with fully-developed profile, the upper horizons of which not only no longer contain debris and detritus of carbonaceous rock, but do not even effervesce from HCl. Classification of this group of soils into subgroups in USSR soil systematics is made according to the stages of their development from solid rock to the zonal group (primitive, calcareous, leached, podzolized). The Polish soil scientists limit the burozem rendzinas to soils with a neutral reaction, or even to those which effervesce from the surface, and in the following stages of development these soils are incorporated with the zonal soils (burozems).

In comparing the rendzinas of Poland with the sod-carbonate soils of the Soviet Union, we found that as in soils of the podzolic group, there is a comparatively low humus content in the A_1 horizon (1%-3%), i. e. they are similar to the sod-calcareous soils of our western republics. It seems to us that this once again corroborates our opinion concerning the specifics of soil formation in the western province.

Soils without clearly defined podzolized or compact illuvial horizons are related by the Polish soil scientists to the burozem group. In these soils the grey-cinnamon brown, humus accumulative surface horizon gradually changes, through the cinnamon-brown B horizon, into soil forming material. In many instances there are signs of gleying (pseudogley) in the B horizon. The presence of sesquioxides is considered characteristic of these soils. These show no transformation throughout the profile, however. Their occurrence is related to peculiarities of weathering and soil formation forms, i. e. in the final analysis, to the bioclimatic conditions of their formation. In characterizing burozems, the Polish soil scientists also emphasize intensity of the biological cycle of materials and the considerable intake of bases in the surface horizons.

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[1] On a German primitive soil on all parent materials (not necessarily consolidated) with fragmentary horizon A, it has essentially only a surface C horizon which is called "sierozem." In soils developed on consolidated material having A horizon, the profile AC is referred to as ranker group.

From the foregoing it is evident that the position of the Polish soil scientists regarding the classification of the burozem group is basically the same as that of the Soviet soil scientists.

In Polish soil systematics three subgroups are distinguished in the burozem group: 1) typical burozems, 2) leached burozems, and 3) acid burozems. The first two subgroups are formed on calcareous rock and differ among themselves according to depth of effervescence. The typical burozems effervesce from the surface, or, at any rate, their surface horizons have a neutral reaction. In the leached burozems the reaction of the surface horizons is slightly acid. Throughout the entire profile the acid burozems have a low pH value and a large amount of "exchangeable Al" is present. This burozem subgroup is found only in the Carpathians (mountain brown forest soils).

Typical and leached burozems formed in lowlands are usually associated with soils of the podzolic group and are "impregnated," so to speak, in their masses. No geographic pattern (longitude and lattitude) has been observed relative to their occurrence, at least in the central and eastern parts of the Republic where the field trips took place. We do not understand why, in insular sections, where the burozems are formed, weathering processes of primary minerals and decomposition processes or organic residue and secondary clay minerals can occur in a different manner than in the surrounding territories with soils of the podzolic group.

In Polish soil systematics nonpodzolized soils that are developed primarily on residual-calcareous rock are related to the burozems of lowlands. It is still not clear to us, from the material on hand, whether these soils represent an independent burozem group, or whether they represent a transitional stage from the rendzinas to podzolic soils. It is especially unclear in view of the fact that the natural peculiarities in Poland evidently make this stage a more stable and prolonged one than in the provinces to the east. Under certain conditions the occurrence of nonpodzolized soils may be caused not only by calcium carbonates, but by a certain admixture of nonweathered primary minerals (micas, feldspars) which are sufficiently good conductors of bases to remove the podzolic when the weathering processes and biological cycle are sufficiently intensive. Such cases have been observed in Belorussia.

To summarize, we find that Polish and Soviet soil scientists agree on the main features in the determination of soil groups, but that the available material was insufficient to determine a burozem group in lowlands. Cooperative work is still necessary in the study of the typical and leached burozems of Poland, as well as of the leached, podzolized, sod-calcareous and nonpodzolized sod soils on non-calcareous rock of our western territories. Research should be directed toward clarifying the nature of the burozem formation process and the nature of conversion and migration of organic and mineral substances.

Chernozems in Poland cover a comparatively small area. They are formed on loess-like clay loams in the Carpathian forelands. Most of them are cultivated. The chernozem group in Polish soil systematics is subdivided into two subgroups: 1) degraded, and 2) non-degraded chernozems. As was shown during the field trips, the Polish soil scientists include the dark grey and partially grey forest soils in the degraded chernozem subgroup, in addition to the chernozems. There are no independent grey forest soils in the soil systematics of Poland. The dark grey and grey forest soils of Poland have a comparatively thick A_1 horizon (40-50 cm) which is followed by a very well defined nut-like A_2B horizon which is rich in powder-like silica. Effervescence from HCl takes place in them below a meter and a half. Humus content in the A_1 horizon varies from approximately 2% to 5%. The degree of podzolization varies.

It is worth mentioning that during the past few years secondary podzolic or sod-podzolic soils with a second humus horizon have begun to be distinguished in the composite soil maps of the USSR. These are soils of the northern forest steppe borderlands which, in addition to well defined podzolization, have residual characteristics which are characteristic of the grey forest soils (sections, or an entire humus horizon with nut-like structure beneath the A_2 horizon). Similar soils occur frequently in Poland, as we observed during the field trips. The Polish soil scientists place them in the podzolic group. Their specific characteristics are not emphasized and they are not found on the soil maps.

The nondegraded chernozem subgroup includes soils which are distinguished in the Soviet Union as podzolized and leached medium thick chernozems with low humus content. They are very similar to the chernozems of the western Ukraine. Their outstanding characteristic is a comparatively low humus content in the A_1 horizon (4%-6%) which, it may be assumed, is caused by the activity of the biological processes and the deep leaching of the calcium carbonates (130-150 cm). We are inclined to explain the latter by the great moisture in the region.

In conclusion let us examine the systematics of the bog soils.

Bog soils are widely prevalent in Poland, especially in the northern regions. Their study and systematics are therefore of great importance. In Polish soil systematics the bog soil group is divided into six subgroups in accordance with the degree of water-logging. It includes both soils at the initial stage of this process, i. e. bogged (gleyed) mineral soils with a complete absence of peat cover, and thick peat deposits.

The concept of a "bog soil group" is therefore more generalized in Poland and includes actual bog (hydromorphous) soils and semibog (semihydromorphous) soils that differ greatly from each other both in profile structure (and consequently formation processes), and agricultural value. Here again, however, this has to do only with the taxonomic evaluation of these differences. In the subgroups, a clear differentiation is always expressed.

Peat soils are classed according to the nature of the peat: lowland, transitional, upland, and its thickness (<20, 20-50, 50-100, 100-200, and >200 cm).

Also classified as subgroups are soils that are characterized by the degree of drying of the bog masses and the "degradation" of the peat mass connected with this, and the conversion of the upper horizons into humus ("amorphic humus") owing to decompositional processes which occurred long ago. In Polish literature this process of decomposition is called the "mursh" process and the soils in which this occurs are called mursh soils. Great attention is given to the dispersion of the humus as a result of excessive drying. During overdrying the organic colloids irreversibly coagulate, lose their ability to swell, and in the form of a friable, dust-like and to a great extent, inert, mass, make up the basic part of the plow horizons of the dispersed mursh and mursh-like soils. These dispersed mursh soils, because they are unfit for agriculture, are expressed in all soil maps as independent areas. The taxonomic position of this soil group remained unclear to us. If there is to be an agreement between the systematics of bog soils in the Soviet Union and in Poland, an agreement should first of all be reached regarding the taxonomic evaluation of phenomena. It may be assumed that once a determination of basic taxonometric units has been agreed upon, this will present no difficulties.

In summarizing, we see that all the soil groups of Poland, as compared with those of the European part of the Soviet Union, have, in addition to common features, many substantial differences. These specifics are caused by Poland's location between two bioclimatic regions: mild maritime, and continental intracontinental. The peculiarities of the Polish soils are so great that it would seem justifiable to us to separate them into independent 'provincial' subgroups of the respective soil groups.

An agreement or soil classification of the USSR and Poland was not completely achieved, as may be seen from the foregoing. We are convinced, however, that with cooperative work this is perfectly possible.

TRENDS IN VITICULTURE IN NORTHERN BULGARIA IN RELATION TO SOIL AND CLIMATE

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The fact that it is possible to grow grapes under various natural conditions in northern Bulgaria has created the impression among many viticulturists that all types of soil, with the exception of alkali and waterlogged soils, are equally suitable for vineyards. Experience has shown that these views are unfounded.

It has been established that slips from the same grapevine, when set in different soils, will produce different harvests. There is frequently found a grape variety which produces high quality grapes, but when re-set in other soil-climatic conditions, begins to produce grapes of another quality. On this question Zubiiatian (3) has written: "When the 'Kaberne' grape variety was grown on the cinnamon-brown soils of the Ararat valley and was irrigated, its sugar content amounted to 20%, and its acidity was 4%-5%. This same variety, when grown on the cinnamon-brown soils of the foothill zone of the Noiambriansk region produces a grape with a sugar content of less than 17% and its acidity increases to 7%." The famous Bulgarian variety "Cherven miskit" which is grown in the Levskigrad area on coarse and detrital soils of the deluvial type has an excellent flavor and delicate aroma. The same variety, when grown on the leached chernozems of the Pleven area, produces a grape differing greatly in flavor and aroma from the Levskigrad grapes. In addition to soil and climate, geomorphological factors in cultivation have a decided effect on quality and yield.

We know from literature (2, 3, 7) that in Italy, France, the USSR, and other countries, most vineyards which produce high-quality wines are located in areas with varying relief, and the vineyards themselves are often located on slopes. The exposition of the slope has a definite effect on vine culture.

In the Bulgarian region with a high temperature growing period, e. g. the Svishtov, Nikopol, and Oriakhov regions, grapes that produce good table wines can be grown on the northern slopes. The southern slopes in these regions are more suited to producing grapes with the high sugar content essential for dessert wines. In the Balkan regions with a low temperature growing period, e. g. Teteven, Troian, Elen, Drenov, Berkov, etc., the southern, southwestern, and southeastern slopes are usually chosen.

Thus there is every reason to believe that soil and macro and mesoclimatic conditions are very important in the obtaining of high quality wines used in champagnes and cordials. The problem of the relationship between the grape variety and ecological factors in its growth (climate, soil, relief, etc.), has been insufficiently worked out for Bulgaria.

Based on literature and our own observations, we have attempted to work out the problem of the trend of viticulture in northern Bulgaria from the standpoint of soil and climatic conditions. When more detailed research in this sphere has been made, our plan will doubtlessly be somewhat altered. We believe, however, that even in its preliminary form it can to a certain extent be beneficial in selecting land for new vineyards in northern Bulgaria.

Viticulture in northern Bulgaria may produce the following in accordance with soil and climatic conditions: dessert wines, champagne, dessert and transportable dessert grapes for export and domestic consumption.

A. Dessert Wines

In areas where grapes are raised for dessert wines the total temperature during the growing period should exceed 3800-3900°C. Mean annual precipitation may vary between 500 and 600 mm and should decrease to a small amount in autumn (Table 1).

Vines should be planted on southern and southwestern exposures exclusively. Soils should be coarse texture, friable, with good thermal and moisture regimes, capable of moderate moisture retention. Humus content

Table 1

Mean monthly and annual temperatures (°C) and mean monthly, seasonal and annual precipitation (mm) (City of Svishtov, 1916-1945)

Indices	Months												Annual	Winter	Spring	Summer	Fall
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII					
Temperature	1.9	-0.2	6.5	13.2	18.1	21.9	23.8	23.0	18.9	13.1	7.2	0.6	12.0	—	—	—	—
Precipitation	38	26	33	50	50	83	53	31	34	44	43	50	537	114	133	169	121

Table 2

Characteristics of shallow calcareous chernozem with low humus content on loess, in the vicinity of Svishtov

Depth, cm	pH	$CaCO_3$	Humus (Tyurin)	Total nitrogen (Kjeldal)	Available P_2O_5	Available K_2O	Particle diameters <0.001 mm, %	Loss from HCl treatment	Total % of particles <0.01 mm in diameter	Particle density	Bulk density	Porosity, %
		percent			mg/100g of soil							
0–20	8.1	2.5	2.2	0.115	>60	19	16.11	14.41	27.37	2.69	1.60	40.5
20–34	8.2	3.1	2.1	0.109	>60	18	14.19	21.59	25.26	2.72	1.50	43.1
34–50	8.1	12.4	1.8	0.090	60	14	14.16	24.14	22.86	2.72	1.51	44.5
50–70	8.3	19.5	1.3	—	50	12	12.51	27.92	20.99	2.72	1.50	44.8
70–110	8.2	19.8	0.8	—	40–50	8	10.85	28.42	19.32	2.71	1.50	44.9

should be approximately 1.5%-2.5%. The presence of $CaCO_3$ and phosphorus and potash supplies are essential (Table 2). Rubble and detritus in the soil layers are also beneficial to vine development. Soils which satisfy these requirements are:

1) Calcareous chernozems, shallow, medium, and deep, with low humus content on loess, eroded and noneroded.

2) Calcareous chernozems, shallow, medium, and deep, with low humus content, on limestone, noneroded, slightly and medium eroded.

3) Typical chernozems, highly micellar, shallow and medium, with low humus content on loess, slightly and medium eroded.

4) Typical chernozems, highly micellar, deep, with low humus content, on loess, slightly and heavily eroded.

5) Typical chernozems, highly micellar, shallow and deep, with low humus content, on loess.

6) Typical chernozems, deep micellar, shallow and medium, with low humus content, on loess, slightly and medium eroded.

7) Typical chernozems, deep micellar, deep, with low humus content on loess, heavily eroded.

8) Slightly eroded and eroded chernozems, shallow and deep, with low humus content, on loess, medium and heavily eroded.

B. Champagnes

In regions where grapes are raised for champagne wines the total temperature should vary between 2700-3300°C. The mean annual precipitation should be between 600-1000 mm (Table 3). Most favorable are the gentle slopes of the southwestern, southern, and southeastern exposures. There should be good soil aeration and maximum heating. The various

Table 3

Mean monthly and annual temperatures (°C) and mean monthly, seasonal, and annual precipitation (mm) (City of Drianovo, 1916-1945)

Months												Annual	Winter	Spring	Summer	Fall
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII					
—1,4 46	0,2 39	5,6 44	11,4 68	16,9 94	19,5 106	21,7 88	21,4 56	17,6 44	12,3 58	6,2 50	66 54	10,9 747	— 139	— 206	— 250	— 152

Note: Comma represents decimal point.

Table 4

Characteristics of humus-calcareous soils (rendzinas) in the vicinity of Drianovo

Depth, cm	pH	$CaCO_3$	Humus (Tyurin)	Total nitrogen (Kjeldal)	Available P_2O_5	Available K_2O	Particle diameter <0.001 mm, %	Loss from HCl treatment	Total % of particle <0.01 mm in diameter
		%			mg/100g of soil				
0—18	8,2	18,8	2,8	0,101	50	16	36,18	14,09	53,60
18—38	8,3	22,4	2,9	0,092	50	12	32,05	20,50	50,05
38—59	8,2	34,1	2,8	—	40	10	20,61	38,91	40,09
59—82	8,3	57,6	—	—	41	8	18,06	49,05	33,65

Note: Comma represents decimal point.

detrital and stony soils are the most favorable, but the clay content should be comparatively high, (18%-25%).

The calcium carbonate ($CaCO_3$) content should be from 15%-50% (Table 4). The following soils meet these requirements:

1) Humus calcareous (rendzinas), shallow, medium, and deep, with low humus content, eroded, and noneroded.

2) Slightly, heavily, and medium podzolized chernozems, shallow and medium, with low humus content, on loess and loess-like clays, medium and heavily eroded.

3) Dark grey forest soils, shallowly underlain by calcareous material, with low humus content, on loess-like and calcareous clays, heavily and medium eroded.

4) Dark grey forest soils, deeply calcareous, low in humus content, on loess-like and calcareous clays and clay loams, heavily and medium eroded.

5) Dark grey forest soils shallowly underlain by calcareous material, with low humus content, on loess-like and calcareous clays and clay loams.

These same soils may be used when on northern and northwestern slopes, only, however, if the total temperature during the growing period exceeds 3300°C.

In northern Bulgaria these soils occur in the Drianov, Troian, Elen, Teteven, Berkov, and other areas.

C. Table Wines

In regions where grapes are raised for table wines the temperature during the vegetation period should vary between 3500 and 3700°C, and mean annual precipitation should be 600-800 mm (Table 5). Most favorable are moderately moist soils which are well aerated and with sufficient thermal capacity. The humus content should be greater than in soils recommended for dessert and champagne wines.

Table 5

Mean monthly and annual temperatures (°C) and mean monthly, seasonal and annual precipitation (mm) (City of Sukhindol, 1916-1945)

Months												Annual	Winter	Spring	Summer	Fall
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII					
—1,4	0,4	6,0	12,1	16,8	20,4	22,4	22,4	18,6	13,4	65	0,6	11,5	—	—	—	—
40	33	38	65	83	87	68	50	37	56	46	56	659	129	186	205	139

Note: Comma represents decimal point.

Table 6

Characteristics of typical chernozem, medium deep, low humus content on loess-like clay in the vicinity of Sukhindol

Depth, cm	pH	$CaCO_3$	Humus (Tyurin)	Total nitrogen (Kjeldal)	Available P_2O_5	K_2O	Particle diameter <0.001 mm, %	Loss from HCl treatment	Total % of particles <0.01 mm in diam.	Particle density	Bulk density	Porosity, %
		%			mg/100g of soil							
0—10	7,8	not det	2,6	0,120	60	19	36,55	4,22	53,47	2,73	1,37	49,7
10—30	7,6	„	2,4	0,128	60	18	28,70	3,68	55,67	2,67	1,70	36,4
30—55	8,1	2,9	2,1	0,090	60	19	36,85	6,84	53,86	2,69	1,79	33,5
50—80	8,3	26,8	1,2	—	50	17	28,71	31,96	36,30	2,72	1,75	35,6
80—110	8,2	25,8	0,9	—	50	11	22,82	30,16	36,41	2,76	1,68	40,0

Note: Comma represents decimal point.

Especially important is a good supply of phosphorus and potash (Table 6). Such soils are:

1) Typical chernozems deeply micellar, shallow, medium, and deep, low and medium humus content, on loess-like clay loams and clays, noneroded and slightly eroded.

2) Slightly leached, leached, and heavily leached chernozems, shallow, medium, and deep, low and medium humus content on loess-like clay loams and clays, noneroded and eroded.

3) Slightly, medium, and heavily podzolized chernozems, deep, medium, and shallow, low and medium humus content, on loess-like clay loams and clays, eroded and noneroded.

4) Dark grey forest soils, shallowly underlain by calcareous materials, shallow, medium, and thick, low and medium humus content on loess-like clay loams and clays, calcareous clays, eroded and noneroded.

5) Dark grey forest soils deeply underlain by calcareous clays, shallow, medium, and deep, low and medium humus content, on loess-like clay loams, and clays, and calcareous clays, slightly and heavily eroded.

6) Brown forest soils, shallow, medium, and deep, low and medium humus content, on clay loams and clays, noneroded and eroded.

7) Grey forest soils, shallow, medium, and deep, low and medium humus content, on loess-like clay loams, and clays, and calcareous clays, eroded (heavily, medium, and slightly).

These soils cover a large area in the foothill- and mountain regions of northern Bulgaria and Dobruja. Northern Bulgarian temperatures allow grapes to be grown successfully for table wines on both northern and southern slopes. This is especially true in the Kraidunai region where summer temperatures are highest.

Primarily suitable for grape varieties used n the production of white wines with low alcoholc content are the coarse soils (sands and heaviy skeletal soils) found in Levskigradsko, Pazrdzhisko, Pomorie, the Songular valley, and lsewhere. In northern Bulgaria such soils re rarely found, resulting in limited producion of white wines.

D. Transportable Dessert Grapes

Average total temperature during vegetation eriod 3800°C, mean annual precipitation 500- 00 mm with smallest amount falling during eptember and October (Table 7). Soils are oarse textured, friable, but with sufficient noisture retention capacity, and with humus ontent not exceeding 3%. The $CaCO_3$ content nust be assured, as well as average amounts f nitrogen, phosphorus and potash (Table 8). oils meeting these requirements are:

1) Calcareous chernozems, shallow, medium, and deep, low and medium humus content, on loess, eroded and noneroded.

2) Calcareous chernozems, shallow, medium, and deep, low and medium humus content, on limestone, eroded and noneroded.

3) Typical highly micellar chernozems, shallow, medium, and deep, low and medium humus content, on loess, eroded and noneroded.

4) Typical deeply micellar chernozems, shallow, medium, and deep, low and medium humus content, on loess, loess-like clay loams, eroded and noneroded.

5) Slightly leached and leached chernozems, shallow, medium, and deep, light and medium humus content, on loess and loess-like clay loams or clays, eroded and noneroded.

Table 7

Mean monthly and annual temperatures (°C) and mean monthly seasonal and annual precipitation (mm) (City of Pleven 1916-1945)

Months												Annual	Winter	Spring	Summer	Fall
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII					
−1,8	0,4	5,8	12,5	17,3	21,0	23,5	22,8	18,8	13,1	6,2	0,1	11,6	—	—	—	—
35	28	29	54	75	83	70	37	37	48	45	44	585	107	158	190	130

Note: Comma represents decimal point.

Table 8

Characteristics of typical chernozem, medium deep, low humus content, on loess, slightly eroded, in the vicinity of Pleven

Depth, cm	pH	$CaCO_3$	Humus (Tyurin)	Total nitrogen (Kjeldal)	Hydrolized nitrogen mg/100 g of soil (Tyurin)	Available P_2O_5	Available K_2O	Particles diameter <0.001 mm, %	Loss from HCl treatment	Total % of particles <0.01 mm in diam.	Particle density	Bulk density	Porosity, %
		%	%	%		mg/100g of soil	mg/100g of soil						
0—20	7,1	not det.	1,7	0,108	60	60	17,0	30,85	2,09	47,85	2,71	1 64	39,5
20—40	7,6	"	1,8	0,115	50	50—60	14,0	31,33	2,02	48,62	2,72	1,62	40,5
40—60	8,1	14,3	1,4	0,080	40	50—60	10,5	23,81	18,08	38,63	2,73	1,52	44,5
60—80	8,4	30,0	1,1	0,060	16	50—60	10,0	16,40	35,72	28,07	2,73	1,56	43,0
80—100	8,3	34,0	0,9	—	9	40	17,5	16,48	39,35	26,72	2,72	1,62	40,0
100—120	8,3	32,0	0,7	—	—	40	10,0	18,95	36,31	29,00	2,72	1,44	47,0
120—140	8,3	28,0	0,5	—	—	40	9,0	22,90	31,90	31,00	2,71	1,46	46,2

Note: Comma represents decimal point.

6) Slightly and medium podzolized chernozems, shallow, medium, and deep, light humus content and medium humus content, on loess and loess-like clay loams and clays, eroded.

7) Soils of alluvial-deluvial formation. Most favorable are those developed on loess-like materials which occur primarily in the region bordering the Danube from Lom to Ruse. The high temperatures of this region allow grapes to be grown on both southern and northern slopes.

Beside the Kraidunai belt, the following areas are suitable for the production of high quality transportable dessert grapes: Pleven, Gorno-Orekhov, Liaskov, Preslav, and others where coarse, friable, well-warmed calcareous soils occur.

Requirements for the production of other dessert grapes for export and domestic use are the same as for transportable dessert grapes. The early varieties should, as a rule, be grown on slopes with a southern and southwestern exposure.

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AN EXPPERIMENT TO ESTABLISH THE RELATIONSHIP BETWEEN CONTENT OF EXCHANGEABLE CALCIUM AND POTASSIUM, AVAILABLE PHOSPHORUS AND TOTAL NITROGEN IN HUMUS-PODZOLIC HORIZONS OF FOREST SOILS[1]

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The objective of this experiment was to study adsorbed calcium, potassium and phosphorus content in forest soils and their mutual association and function in this mineral and organic part of the soil. Special attention was given to the humus-podzolic horizons (A_1 horizons).

The humus-podzolic horizons have long attracted the attention of investigators. Their presence in the profile of podzolic soils was regarded as a favorable characteristic. In forestry the concept of soft humus (mull) was associated with these horizons, and in agriculture, with the sod process. This research was carried out with the purpose of establishing the mathematical relationship between the basic nutrient content in the soil (nitrogen, phosphorus, and potassium).

We also associate the nutrient content with he presence of calcium. We have repeatedly emphasized processes in this function of soil formation in our works.

Samples from the A_1 horizon were analyzed for exchangeable calcium, potassium, mobile phosphorus, and total nitrogen. Exchangeable calcium and potassium were determined by extraction with 0.05 n of HCl according to K. K. Gedroits' method. Available phosphorus was extracted by 1% citric acid (König and Hasenheimer's method). This form of phosphorus s evidently associated primarily with the phenomena of chemical adsorption. Total nitrogen was determined by Kjehldal's method ccording to Jodlbauer's modification.

Mention should be made of the problem of the diagnostic forms of phosphorus in the soil, as these are not sufficiently well determined from the chemical or physicochemical standpoints. This problem, however, may be considered less pressing in view of N. M. Sibirtsev's research. According to this author (1) the following magnitudes of correlative coefficients have been established between forms of phosphorus in the soil which differ according to availability:

1. Correlation coefficient between total P_2O_5 and soluble P_2O_5 in 10% HCl, + 0.97.
2. Correlation coefficient between P_2O_5 and soluble P_2O_5 in 1% HCl, + 0.73.
3. Correlation coefficient between P_2O_5 and soluble P_2O_5 in 10% and 1% HCl, + 0.77.

These figures indicate a very high correlation between the content of forms of phosphorus in the soil which vary according to availability.

Samples for analysis were taken from the A_1 horizon of soils formed on ordinary glacial deposits under coniferous and coniferous-deciduous forests in the Leningrad, Kalinin, and Moscow regions.

The contents of calcium, potassium, phosphorus, and nitrogen are expressed in mg per 100 g of dry soil and are given in Table 1.

In studying the experimental results, we were interested in the following problems: 1) form and degree of relationship between the content of the substances studied, 2) the function of calcium and nitrogen (humus) in determining the content of available forms of potassium and phosphorus in the horizons studied. We characterized the form and degree of relationship between content of the determined substances by the empirical formulas and correlative coefficients[2] given in Table 2. We took

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[1] Editorial Note:
The relation of exchangeable bases to the clay nd humus content in the soil has been determined more recently. In this paper it was determined by sing correlation coefficients and empirical formulas. At present it is difficult to say how expedient s the determination of empirical formulas for relaively small coefficients of refraction.

[2] The correlative coefficients were determined according to the formula

$$r = \frac{\sum(x - \overline{x})(y - \overline{y})}{\sum(x - \overline{x})^2 (y - \overline{y})^2}$$

Table 1

Content of exchangeable calcium and potassium, available phosphorus and total nitrogen in the humus podzolic horizons of forest soils

Soil profile No.	mg/100g of dry soil				Soil profile No.	mg/100g of dry soil			
	Ca	K	P	N		Ca	K	P	N
1	20	4	6	43	21	102	20	18	189
2	27	6	5	84	22	106	13	9	312
3	31	3	4	96	23	109	17	14	138
4	34	8	3	60	24	115	8	12	234
5	37	7	7	102	25	122	24	18	160
6	38	4	4	139	26	125	17	15	323
7	41	5	5	69	27	128	18	10	249
8	44	5	10	65	28	131	25	17	209
9	45	11	12	114	29	139	16	7	323
10	55	6	4	58	30	144	10	18	386
11	62	5	6	172	31	147	20	14	165
12	70	14	14	148	32	161	33	12	310
13	78	7	10	102	33	164	14	16	336
14	79	9	4	279	34	168	21	12	201
15	80	10	6	172	35	168	32	16	458
16	82	15	9	156	36	172	36	30	324
17	88	18	15	240	37	178	15	11	209
18	92	8	6	165	38	186	16	10	445
19	96	19	7	254	39	193	38	31	210
20	100	7	17	207	40	202	22	17	387

Note: Comma represents decimal point.

Table 2

Form and degree of relationship between content of exchangeable calcium and potassium, available phosphorus and total nitrogen in the humus-podzolic horizons of forest soils
(value of y)

Determination	When z=exchangeable calcium		Determination	When x=total nitrogen	
	Empirical formulas of assoc.	Coefficient of correlation		Empirical formulas of assoc.	Coefficient of correlation
Total nitrogen	y = 2 x	+0.78	Calcium	y = 0.5 x	+0.78
Potassium	y = 0.14 x	+0.77	Potassium	Not determined because of the small bonding force	+0.55
Phosphorus	y = 0.10 x	+0.67	Phosphorus		+0.43

calcium and nitrogen as independent variables.

The expressions in Table 2 show that betwee the contents of exchangeable calcium and potassium, common nitrogen and mobile phosphorus, there exists a rectilinear relationship. This relationship is expressed numerically in the high correlative coefficients and the proposed empirical formulas. Between contents of common nitrogen, exchangeable potassium, and especially mobile phosphorus, the degree of bonding is considerably less (lower values of correlative coefficients).

It should be noted that we characterize the relationship by empirical formulas, not by regression equations. Although the regression equation calculation is the more objective method, it nevertheless expresses to a considerable degree the imperfection of the experimental material. We use regression equation calculation for control of the obtained empirical formulas. The latter, in the given instance, were established by a simplified method based on graphs. The given formulas cannot be employed in determinating the content of any soil compounds. We are dealing here with correlations, not with functional relationships. This allows a considerable divergence of the unknowns in individual cases.

It should also be pointed out that a high degree of correlation is observed between the content of exchangeable potassium and available phosphorus in the humus-podzolic horizons (correlation coefficient, + 0.77).

The second problem: the function of calcium and humus in determining the values of the available forms of potassium and phosphorus in the A_1 horizon of podzolic soils should evidently be solved on the basis of the data obtained, owing to the large calcium value. The data given in Table 2 show that the degree of bonding between content of calcium (x), potassium, and phosphorus is considerably greater (correlative coefficient, + 0.77 and + 0.67) than between the content of nitrogen (x), potassium, and phosphorus (correlative coefficient, + 0.55 and + 0.43).

Since a functional relationship in the A_1 horizon between the nitrogen and humus content exists, the humus accumulation in these horizons may not be considered a determining factor in relation to the amounts of potassium and phosphorus studied. The materials obtained point to the fundamental role of exchangeable calcium and its regime. Our earlier experiments showed (2) that exchangeable calcium determines the accumulation conditions of humus in the A_1 horizon of podzolic soils and also accumulation conditions of nitrogen. The present work confirms this.

The determining role of calcium in the formation of the humus-podzolic horizons emphasizes the significance of the mineral part of the soil in determinating the regime of nutrients in these horizons. In the observed cases it is the basic source of calcium. Basic sources of nitrogen are associated with the atmosphere, but calcium contributes to the accumulation of this element in the soil by fixing it in the form of organic compounds.

It should be noted here that exchangeable calcium content in the soil profile is determined considerably by the presence of clay particles. The relationship between the values of exchangeable calcium and physical clay (particles <0.01 mm in diameter) for ordinary glacial deposits under conditions of the podzolic zone may be illustrated by the mathematical expressions in Table 3, where x — physical clay in percentages, y — exchangeable calcium in mg per 100 g of dry soil.

The figures in Table 3 also show the great difference in the effect of clay on the content of exchangeable calcium in the various genetic horizons. This is illustrated by the sharply differing coefficients of the proposed empirical formulas — 2.5 and 1.1. The data obtained, however, do not permit us to speak of a similar role of the clay particles in the humus-podzolic A_1 horizons. The value of the correlation coefficient here is insufficient to affirm the leading role of clay. As a result we do not express its quantitative effect.

It may also be assumed that the significance of clay for the exchangeable calcium content in podzolic (A_2) horizons decreases from the change in the composition of the exchangeable cations and the character of the mineral adsorption complex, but the high degree relationship is maintained (Table 4). The lowering of the degree of relationship between the clay particle and exchangeable calcium content in the humus-podzolic horizons (A_1) should be considered as a result of the increased role of the humate section of these horizons. Hence we may draw the conclusion that in the humus-podzolic horizons the exchangeable calcium begins to become independent of the clay, and as it contributes to the accumulation of humus, its independent role increases.

The content of adsorbed calcium and potassium, available phosphorus, and total nitrogen in the humus-podzolic (A_1) horizons made it possible to establish the form and degree of relationship between the contents of the elements studied mathematically. The form of relationship was characterized by empirical equations, the degree of relationship by correlation coefficients.

The quantitative relationship between the values of exchangeable calcium and physical clay (particles less than 0.01 mm in diameter) were well-expressed for the mineral horizons (B, C, and A_2) of podzolic soils only.

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Table 3

Empirical formulas for relationship and correlation coefficients between physical clay and exchangeable calcium for various genetic horizons of podzolic soils

Genetic horizons	Empirical formulas for relationship	Correlation coefficient
Illuvial and parent material (B and C)	y = 2.5 x	+0.90
Podzolic (A_2)	y = 1.1 x	+0.82
Sod-podzolic (A_1)	"	+0.56

Table 4

Content of physical clay and exchangeable calcium in various genetic horizons of podzolic soils

Soil Pro. No.	Hor. B and C		Hor. A_2		Hor. A_1		Soil Pro. No.	Hor. B and C		Hor. A_2		Hor. A_1	
	Clay, %	Exch. calcium mg	Clay, %	Exch. calcium mg	Clay, %	Exch. calcium mg		Clay, %	Exch. calcium mg	Clay, %	Exch. calcium mg	Clay, %	Exch. calcium mg
1	86,1	257	70,5	70	69,5	42	21	32,0	104	24,7	16	37,0	75
2	78,3	164	67,8	54	67,9	148	22	31,2	75	24,5	51	36,5	49
3	75,4	235	65,2	96	64,5	118	23	30,1	42	24,2	10	36,3	44
4	74,1	118	63,3	54	62,5	68	24	29,3	86	23,8	43	36,2	34
5	73,2	221	63,0	78	62,0	88	25	28,8	120	21,6	11	34,1	6
6	71,7	198	59,2	78	61,7	112	26	25,1	82	14,7	14	32,0	92
7	66,1	220	51,3	78	60,0	43	27	25,0	120	12,2	32	31,9	102
8	63,5	181	46,9	34	59,5	62	28	23,2	27	12,0	20	29,2	20
9	55,2	132	42,9	90	51,5	158	29	20,1	37	11 5	6	24,3	28
10	46,8	72	41,7	52	50,5	47	30	18,2	75	9,3	20	19,1	39
11	44,9	121	39,5	34	49,9	72	31	17,3	36	8,2	2	18,0	46
12	44,1	175	37,7	21	44,6	74	32	15,1	53	7,5	5	16,5	72
13	42,2	184	37,2	26	42,8	156	33	14,8	30	6,7	6	16,1	22
14	42,1	142	36,7	22	39,5	40	34	13,1	47	6,6	10	13,1	26
15	42,1	110	35,5	16	39,5	70	35	10,1	23	4,4	4	12,8	72
16	40,0	102	34,4	27	39,0	72	36	9,1	35	3,8	7	9,3	20
17	39,5	96	34,0	68	38,1	32	37	8,0	21	2,6	2	7,8	22
18	38,4	117	33,1	20	38,0	82	38	4,0	16	2,3	6	5,2	10
19	37,5	82	32,6	22	37,5	17	39	2,4	10	2,1	4	3,6	24
20	33,1	74	28,9	17	37,3	17	40	1,5	4	0,6	6	3,6	6

Note: Comma represents decimal point.

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FFICIENCY OF FERTILIZERS IN SOILS F THE NON-CHERNOZEM BELT OF OB REGION

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In the non-chernozem belt of Ob region, vhich generally coincides with the present-lay territory of Tomsk region, land under culivation includes leached chernozem, dark-rey, grey, and light-grey forest soils, as vell as sod-podzolic soils, which,zonally, hange with each other from south to north. rey and podzolic soils of all three subgroups redominate in the southern part of the region, vhile in the northern portion the soil is preominantly sod-podzolic.

Kuznetsov (4) has shown in his studies that ver a period of three centuries of agriculture, articularly when the fallow system of farming vas employed, grey forest soils and leached hernozems in the region under discussion ave not lost their basic genetic features and ave undergone only minor changes toward trengthening of the sod process. Sod-podzolic oils began to be plowed up not more than 30-0 years ago. In the past, fertilizers, if used t all in the zone, were added only in fields ocated near villages and private plots cultiated by kolkhoz members. Basic properties f the foregoing soils are given in Table 1.

Podzolic soils contain even less humus, itrogen, and phosphorus than sod-podzolic oils and they are less fertile. Differences n morphology, chemistry, and geography of oils listed govern the specific response to ertilizers on the part of the crops planted in hem.

To identify the significance of the individual lements of plant nutrients, in 1936 the Tomsk one Station for Grain Economy conducted ield tests of all soils previously mentioned vith the exception of podzol soils. Tests were onducted with five and eight treatments, repicated three and four times. Areas of the est plots were 100-200 m^2. In all cases, dentical agricultural practices were employed. Amounts of fertilizer added were 45 kg/ha of the active substance. Fertilizer was added in the form of ammonium sulfate, normal superphosphate, and sylvinite. In the preceding year, the station had made greenhouse tests on the same basis. All tests were conducted with spring wheat. Over a number of years tests were made with a variety of crops replicated several times, thus making it possible to determine the specificity of fertilizer action with a high degree of confidence. The results obtained define the role of the soils in the efficiency of fertilizers. Effectiveness of each of three nutrient substances (N, P, and K) was determined, with allowance for the fact that the plants were at the same time assured of a supply of two other nutrients. An analysis of the results makes it possible to define the specific action of the different nutrients in soils of the non-chernozem belt of the Ob region.

In leached chernozems the yield of spring wheat is influenced by phosphorus, with nitrogen second in importance. The addition of potassium does not materially affect the yield. Average yields obtained in two series of tests are shown in Table 2.

When total and available phosphorus content in leached chernozem is high, one would not expect the effect of the superphosphate to be equally high; however, results indicate that the contrary is true. Borodich (2), based on tests conducted at the Scientific-Research Institute of Fertilizers (NIU), noted that in chernozems, particularly in leached chernozems, the effect of phosphorus was greatest in a number of cases. Works by Antropov and Erofeyev (1) and Grebennikov (3), as well as many production tests in kolkhozes and sovkhozes, confirmed that the same is true for western Siberia. The presence of large quantities of nitrate nitrogen which always accumulates in cultivated soils apparently contributes to the effectiveness of superphosphate in leached chernozems. For this reason, even if phosphorous fertilizers are added only

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[1] Presented to the First Delegate Session of Soil cientists, May 1958.

Table 1

Basic chemical properties of soils in the non-chernozem belt of Ob region (after Nepriakhin, 6)

Soil	Thickness of humus horizon (cm)	Total content			Available forms			Salt pH	Relative fertility level based on wheat yield (%)
		metric tons/ha in a 50 cm thick layer							
		humus	nitrogen	phosphorus (P_2O_5)	nitrogen	phosphorus (P_2O_5)	potassium (K_2O)		
Leached Chernozem	50	374,3	18,71	7,76	0,40	1,38	0,90	6,6	100
Dark-grey forest	40	429,2	26,68	7,88	0,38	0,41	0,44	6,2	95
Grey forest	30	262,0	14,20	6,43	0,40	0,58	0,36	6,0	83
Light-grey forest	21	203,1	12,09	7,61	0,48	0,65	0,38	5,6	61
Sod-podzolic	14	112,0	7,03	5,00	0,30	0,38	0,32	4,8	48

Note: Comma represents decimal point.

Table 2

Effect of nutrients on wheat yield in leached chernozem

Wheat yield	Nutrients					Increase from:			
	No fert.	NP	NK	PK	NPK	N	P	K	NPK
cntr/ha	17.4	19.6	17.8	18.7	19.6	0.9	1.8	0.0	2.2
%	100.0	112.6	102.3	107.4	112.6	5.2	10.3	0.0	12. 6

intermittently, they appear to be more effective than either nitrogen or potassium fertilizers. The effectiveness of the different nutrients varies, depending on agricultural practices and types of crops cultivated; however, the order of importance of plant nutrients remains the same: P, N, K (7). The effect of phosphorus in leached chernozems increases when fallow is put under early fall plowing, as compared with earlier crops on non-fallow land, or late fall or spring plowing. Nitrogenous mineral fertilizers act more effectively when crops are planted on non-fallow land. Joint use of nitrogen with phosphorous fertilizers in leached chernozems assures highest increases in yield and constitutes a nearly completely efficient fertilizer.

Most of the field and greenhouse tests were conducted with dark-grey forest soils. In addition to spring wheat, winter rye and table beets were used in the tests. Results obtained in all tests indicated that the greatest increase in yield was assured by the addition of potassium fertilizer, while phosphorous or nitrogen fertilizer produced the lowest yield. Results of the tests are presented in Table 3.

In terms of residual effect, too, potassium increases the yield to a greater extent than phosphorus and nitrogen. Data given in Table 4 were obtained in tests with spring wheat conducted by the Tomsk Experimental Station. The highest efficiency of potassium in dark-grey soils is explained by the presence of increased amounts of available nitrogen and phosphorus. In addition, potassium, as is known, is capable of re-using and of exo-osmosis when, after the grain and flax have blossomed, the need for this element is reduced. The specificity of potassium action in dark-grey soils evidently consists in the fact that it improves the availability and utilization of nitrogen and phosphorus. In 1938 Maslova (5) directed attention to the growing significance of potassium fertilizers in connection with the general increase of soil fertility. In western Siberia, dark-grey soils are among the most fertile of the grey forest soil group.

Yields of spring wheat obtained in grey and light-grey forest soils at various points within the jurisdiction of the Tomsk Zone Station are shown in Table 5.

Table 3

Effect of nutrients on crop yields in dark-grey soils, cntr/ha

Crop	No. of tests	Nutrients					Increased from:			
		No fert.	NP	NK	PK	NPK	N	P	K	NPK
Spring wheat	5	14.0	15.2	17.6	16.5	18.1	1.6	0.5	2.9	4.1
Winter rye	1	21.8	21.8	24.5	26.4	27.2	0.8	2.7	5.4	5.4
Table beets	1	105	135	265	268	264	—	—	129	159

Table 4

Comparative residual effectiveness of N, P, and K on yield of spring wheat in dark-grey soil (%)

Year of residual effect	No. of tests	Additional yield of grain from:		
		N	P	K
1st	3	14.4	1.8	26.8
2nd after rye	1	0.8	15.8	37.0
3rd after flax	1	17.0	12.5	39.0

Table 5

Effect of fertilizer on yield of spring wheat in grey forest soils, cntr/ha

Soil	Nutrients					Increase from:			
	No fert.	NP	NK	PK	NPK	N	P	N	NPK
Grey	14.0	18.0	17.6	16.5	19.2	2.7	1.6	1.2	5.2
Light-grey	10.6	13.9	12.7	11.5	15.2	3.7	2.5	1.3	4.8

Here, nitrogen fertilizer is most effective, hosphorus increases the efficiency, and that f potassium changes but little. Such action f the fertilizer can easily be explained by e fact that, in comparison with leached hernozems and dark-grey soils, the grey d light-grey forest soils are lacking in nuients. Tests conducted in the European poron of the USSR (2) with soils of the group der discussion produced similar yield inreases.

In sod-podzolic soils of Ob region the acon of fertilizers appeared particularly efcient.

Tests conducted in the "Krest'yanin" Kolkz, the control point of the Tomsk Experimental Station, produced the following results (Table 6).

The significance of nitrogen fertilizers in sod-podzolic soils is even more apparent than it was in grey-forest soils and leached chernozems. In tests conducted in other years it was determined that in sod-podzolic soil the efficiency of fertilizers also depends on the agricultural practices. When crops were planted on fallow land, the significance of phosphorus and potassium increased; when non-fallow land was cultivated, the importance of nitrogen appeared greater. The most significant influence of nitrogen and phosphorous fertilizers was noted with respect to spring wheat, while that of phosphorus appeared to be great with respect to the winter crops, rye

Table 6

Effect of various nutrients on wheat yield in sod-podzolic soils

Test	Nutrients					Increase from:			
	No fert.	NP	NK	PK	NPK	N	P	K	NPK
Field (cntr/ha)	8. 2	13. 9	12. 7	10.1	14. 8	4. 1	1. 9	0. 7	6.3
Greenhouse (g/pot)	6. 0	13. 6	8. 9	8.2	13. 9	5. 7	5. 0	0. 3	7.9

Table 7

Increases in grain yield, cntr/ha

Nutrients	Winter grain after fallow		Spring grain after plowing	
	Rye	Wheat	Wheat	Oats (residual) effect)
Nitrogen	3. 7	6. 6	5. 2	3. 9
Phos.	5. 7	7. 7	5. 7	2. 6
Potassium	2. 0	5. 8	4. 6	3. 0
NPK	11. 0	12. 0	10. 0	5. 9

and wheat, planted on fallow (Table 7).

The large effect of phosphorous fertilizer with respect to winter crops in these experiments was ascribed to a lack of phosphorus in the soil, which, however, was well supplied with nitrogen. Determination of phosphorus after Arrenius, indicates no great need for phosphorous fertilizer. The content of available phosphorus was in mg of P_2O_5 per 100 g of soil: when no fertilizers were used—18; after NP had been applied—19. 8; after PK—21. 6; after NPK--24. 0; after NK—15. 0. The positive influence of phosphorous fertilizers on winter crops extends also to the increased winter resistance of the crops.

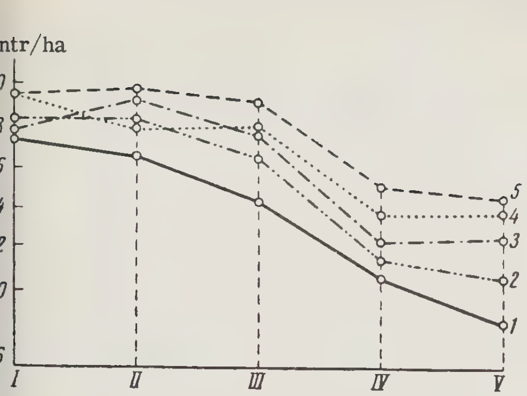
Comparing yield increases, resulting from our experiments with fertilizers in sod-podzolic soils, with data obtained by the NIU, we noted a more significant increase in the yield resulting from nitrogen (49. 4% instead of 33. 0% in the NIU experiments) and almost identical increases in yield resulting from phosphorus. While the different forms of fertilizers vary in their actions, the nutrients, in order of their importance, always line up in the following order: N, P, K. The role of nitrogen and phosphorus becomes even more significant with respect to podzolic soils.

The relative efficiency of the fertilizers added illustrates the role played by the various nutrients. If the level of potassium action on the yield of spring wheat is taken as unity, the relative efficiency of the nutrients can be represented as follows:

	K	P	N
In dark-grey soils	1	0. 3	0. 8
In grey soils	1	1. 3	2. 2
In light-grey soils	1	2	3
In sod-podzolic soils	1	3	6

The conclusion is that the significance of phosphorous and, particularly, nitrogen fertilizers increases in the same measure that natural fertility of the soil in Ob region decreases. The efficiency of phosphorous fertilizer, compared with its action in dark-grey soil, increases in grey soil by a factor of 4, in light-grey soil by a factor of 7, and in sod-podzolic soils by a factor of 10. Going from dark-grey to grey, light-grey forest, and sod-podzolic soils, the efficiency of nitrogen fertilizer increases by a factor of 3, 4, and 7.

In all experiments conducted in Ob region it was noted that the most positive action of fertilizers was achieved when nutrients were used in pairs or when two or three of the primary nutrients were used jointly. In this case, too, the unique action of fertilizers was closely related to the particular soil, as can be seen in Figure 1. In experiments with various fertilizer combinations it was found that wheat yield, for obvious reasons, decreases in the following order: from the more fertile leached chernozems to the relatively infertile sod-podzolic soils. It must be assumed that, by increasing the amounts of fertilizer, the yield of the poorer soils could be raised to the level of the more fertile ones, as had been noted in the NIU experiments. The tests lead to the conclusion that amounts of fertilizer must be varied in accordance with the soil. This is also confirmed by the amounts of manure considered efficient in the soils of Ob region: in dark-grey and grey soils the amount is 20 metric tons/ha, while in light-grey soils it is 30, in sod-podzolic soils it is 40, while in podzolic soils of the Narym Region it is as high as 60 metric tons/ha. The efficiency of manure, as it



ig. 1. - Influence of various fertilizers on the rain yield of spring wheat in different soils.

- leached chernozem; II - dark-grey soil; II - grey forest; IV - light-grey forest; V - od-podzolic soil.

- without fertilizer; 2 - PK; 3 - NK; 4 - PK; 5 - NPK.

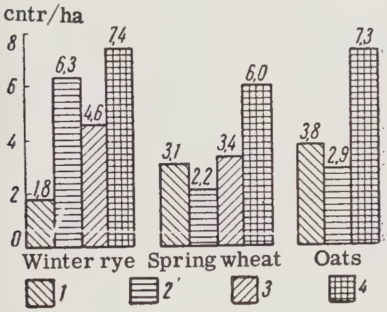


Fig. 2. - Increase in grain yield based on manured soils of Ob region.

1 - dark-grey forest soil; 2 - grey forest; 3 - sod-podzolic; 4 - podzolic soil.

influences the yield of rye, wheat and oats, lanted in various soils, is shown in Figure 2.

The unique action of manure is influenced ot only by local conditions but also by the extural difference between soils. Tests conducted over a period of many years determined hat in sod-podzolic soils of sandy loam at the Narym experimental station the efficiency of ach metric ton of manure is lower than in grey forest clay loams of the Tomsk Experimental Station. In clay loams, when amounts f manure are increased, a noticeable derease in the coefficient of its action is reorted: each metric ton, applied in small mounts produces a greater yield increase vith respect to crop rotation, than a metric on of manure applied in large amounts. In sandy loams of Narym the yield increase per ton of manure is almost independent of amounts applied and the efficiency of the manure added does not vary much with amounts ranging from 20-60 metric tons/ha. In the case of fine textures, increased duration of the residual effect is noted, and the fertilizer nutrients in this case are utilized more uniformly throughout the crop rotation period.

It should be noted that, independent of genetic peculiarities, the cultivated state of the soil exerts great influence on fertilizer efficiency. In soils that have been under cultivation, particularly in sod-podzolic soils that have received no fertilizers, there is an increase in the significance of nitrogen and, particularly, of phosphorous fertilizers. Superphosphates in this case are even more effective than nitrogen fertilizers. Thus, in one of the tests conducted in poor sod-podzolic soils in the "Krest'yanin" Kolkhoz, the yield of spring wheat, after adding superphosphate, increased by 5. 7, upon addition of nitrogen by 5. 3, and upon addition of potassium by 4. 6 cntr/ha.

Thus, experiments in the application of fertilizers in the non-chernozem belts of Ob region during the period from 1932 to 1956 proved the importance of the role played by the soils in correct fertilizer selection.

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ISTRIBUTION OF SOILS IN THE THE MINUSINSK DEPRESSION VITH REFERENCE TO TOPOGRAPHY AND EROSION PROCESSES

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The question of the influence of the topog- aphy of a given location on erosion processes as been considerably discussed in the litera- ire. Speaking of the origin of eroded soils, . V. Dokuchayev stressed that "the topography f a region decisively affects the formation of bnormal soils — alluvial, re-eroded, etc" (4). e added: "... the close relationship between opography and the thickness of soil is illustrated y the following two or three examples taken rom various corners of chernozem Russia. In ne Bakhmutsk uyezd the thickness of the cher- ozems along the upper portion of the south lope was 48 cm, in the center of the slope 1 cm, and at the bottom portion of the slope 6 cm; along the north slope, the thickness of ne upper portion was 48 cm and that at the ottom was 58 cm" (5). In publishing the ma- erial collected on the connection between top- graphy and the formation of eroded soils, he rote that "... they usually occur in the form f islands of various sizes, bands, and bare pots among different other soils and near iverbanks and gullies, near dome shaped ountain tops, hills, and at more or less teep slopes" (6).

The influence exerted by the topography of locality on the development of the soil-forming rocess and the appearance of eroded soils were iscussed in some detail by Vil'yams; he pointed ut that the connection between the topography f a locality and the process of soil formation evident as a result of the influence of soil oisture on the different elements of the opography (1).

In addition to many other investigators, the llowing have studied the relation between soil rosion and topography: Pavlov (10), Izmail'- kiy (7), Pankov (11), Mosolov (9), Sus (14), ozmenko (8), and Sil'vestrov (12). A great eal of material on this subject can be found oth in Russian and in foreign literature. A rief history and review of Russian literature the question of topography and its effect on rosion processes were given in the work of bolev (13).

It should be noted that the wealth of material available on the influence of topography on development of erosion processes is not necessarily applicable to the varied natural-history conditions everywhere in our great country. While these questions have been investigated with respect to the soils of the European portion of the USSR, our knowledge of the enormous territory of the Asiatic portion of the USSR, with its soils that are subject to erosion processes, is still far from adequate. True, in Gorshenin's monograph "The Soils of the Southern Portion of Siberia" (3), as well as in other works by him (2), the development of the Siberian soil is closely related to the development of the topography. However, the question of the extent to which erosion processes are influenced by the manner in which the soil follows the topography of a locality in a large portion of Siberia has not received sufficient attention in the literature. In addition, investigators who study erosion processes in the territory of the USSR, have usually concentrated only on one or another type of erosion (water or wind), while under conditions of various topography of many Siberian regions these two erosion processes are organically tied and interrelated.

The conditions mentioned, and the considerable loss to agricultural production caused by widespread soil erosion, have served as a basis for the study of erosion processes and of controlled measures to be used against erosion by the following Kolkhozes: Dzerzhinskiy, Bograd region, Khakass autonomous region, whose territory is in the Sydino-Erbinsk depression, which forms the north (left bank) portion of the Minusinsk depression in the Krasnoyarsk subdistrict (15, 16).

This paper presents certain data pertaining to the distribution of erosion processes in relation to the topography of a locality and their effect on soil properties and conditions of agricultural crop development.[1]

Two separate slopes were studied: the 1650 m long north slope of a section operated by the fifth field brigade in the region known as "Pod Korovoy," and the 850 m long south slope, on land of the fourth field brigade in the "Kartoshikha" region. In 1957, on July 3-5, "Kitchner" spring wheat was planted after autumn plowing on both slopes with careful observance of comparable conditions (homogeneous spring wheat after clean fallow, uniform methods of soil cultivation, depth of planting, uniform rate of sowing and other agricultural practices).

Spring preparation of the soil consisted of harrowing, followed by disking and harrowing. After sowing the soil surface was left smooth.

On each of the slopes at three areas (the upper, middle and lower part of the slope) experimental plots were established having an area of 20 x 20 m replicated twice. Around each plot one section of soil was dug up and samples were taken for laboratory study.

In samples taken from the surface soil layer (0-10 cm) the following were determined: acidity of the soil solution, by colorimetric methods with the aid of a color scale and the combined Alyamovskiy index; humus, after Tyurin; and particle size analyses, by the pipette method, after Robinson.

Soil moisture was determined on July 14 and 15 to a depth of 1 m at levels of 10, 25, 50, 75 and 100 cm, in triplicate, by use of the drying method. From it, the available moisture to crops was computed. The latter was determined in accordance with the indexes of maximum hygroscopicity (the coefficient of maximum hygroscopicity was taken as 1. 2 for the coarser- and up to 1. 6 for the finer-textured soil). Maximum hygroscopic moisture was determined by the A. V. Nikolayev method. Soil temperatures were measured daily from July 13-18 at 6, 14, and 20 hours, at a depth of 5 cm, with the aid of the Savvinov thermometer.

Wheat was harvested at the end of waxy ripeness. The yield of each plot was accounted for separately. Prior to the harvesting, the height of the plants, as well as the length of the spike, and productive and total stalks were measured.

Quantitative determination of the displacement of soil particles resulting from wind erosion was carried out with the aid of metal stakes having a diameter of 4-6 mm and a length of 50 cm; these were stuck into the ground to a depth of 25 cm, in special plots 1 m square, replicated four times for each section of the slope. Water erosion was measured with respect to special sample plots in which the eroded portions were carefully measured by the Sobolev (13) method. Computation of soil loss from erosion for the period from July 5 through August 19, 1957, was measured from the level of soil surface near the stakes or from the volume of the eroded portions; in converting the quantity of eroded material into metric tons/ha, we took into account the over-all weight of the soil, replicated three times, determined on July 14 and 15 with the aid of a special 100 cc sampler.

The results of the quantitative analysis of erosion processes, physicochemical analysis of soil properties, as well as data on the development and the yield of spring wheat for each slope and for each slope element are given in Tables 1 and 2.

Data in Tables 1 and 2 clearly show the non-uniformity of the soil and the differing conditions affecting growth and development of agricultural crops as a result of the local topography.

In the upper, steeper portion of the south slope (Table 1) located near the top of the mountain, there is southern, thin, gravely-sandy loam and highly eroded chernozems greatly lacking in humus and moisture. Further down the slope the thickness of the humic horizon, humus content, acidity of the soil solution, and the moisture content in the soil increase considerably.

Investigations indicate that there is a significant change in soil texture depending on topography. The upper portion of slope contains predominantly large and coarse fractions with a diameter range of 1-0. 05 mm. The content of smaller particles (ranging from 0. 05-0. 005 mm in diameter) does not exceed 8%; the content of clay fractions is even smaller. Progressively down the slope, the quantity of fine-grained (silty or clay) particles increases and reaches large values in the lower elements of the given slope.

An important factor affecting the growth and development of agricultural crops is soil temperature. Investigations have shown that the mean daily temperature in the lower portion of the south slope is 0. 6-3. 2°C lower

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[1] The following data served as a basis for the above: Observations by G. A. Cheremisinova, one of the authors of this article, jointly with P. K. Dushanina, agronomist of the Dzerzhinskiy kolkhoz, during the period from 1954 to 1957; further, data of the analysis of soil samples, obtained in 1957 by agronomist Z. I. Polezhayeva, co-author of this article, at the General Agricultural Laboratory of the Krasnoyarsk Agricultural Institute.

Table 1

Certain properties of soils, appearance of erosion processes, and development of spring wheat on different sections of the south slope

Indicators	Soil profile of sections of the slope		
	No. 1 upper portion	No. 2 middle portion	No. 3 lower portion talus
Distance downward along slope from top (m)	0	350	400
Gradient (degrees)	9. 6	4. 5	1. 3
Acidity of soil (pH)	7. 7	7. 6	7. 0
Thickness of humus horizon (cm)	17	23	65
Humus (% on dry soil)	4. 35	5. 08	6. 30
Depth of effervescence (cm)	at surface	22	25
Maximum hygroscopic water (in the soil layer from 0-10 cm), %	4. 11	6. 56	6. 73
Content of separates (%)			
>0. 25 mm in diameter	53. 07	45. 01	41. 54
0. 25 —0. 05 "	28. 04	22. 12	20. 01
0. 05 —0. 01 "	8. 03	9. 61	10. 45
0. 01 —0. 005 "	6. 24	6. 55	7. 94
0. 005—0. 001 "	2. 36	7. 70	11. 52
<0. 001 "	1. 26	9. 01	10. 54
<0. 01 "	9. 86	23. 26	28. 00
Soil temperature, °C, at depth of 5 cm (average for the period 7/13-7/18)			
at 6 hrs.	7. 4	8. 7	10. 8
at 14 hrs.	30. 8	29. 3	22. 4
at 20 hrs.	23. 4	21. 6	19. 8
Mean daily temperature, °C	20. 5	19. 9	17. 3
Total of available moisture in a 1 m soil layer (metric tons/ha)	58	193	354
Loss of soil from erosion (metric tons/ha)			
a) wind	9. 82	2. 76	0. 91
b) water	9. 32	0	0
Beginning of milk stage	July 12	July 15	July 16
Height of growth (cm)	42. 4	67. 7	81. 2
Total stalks (no/m^2)	295	396	470
Productive stalks (no/m^2)	188	327	467
Yield (cntr/ha)	12. 3	20. 4	26. 7

han that at the upper elements of the slope. he lower elements of the slope have smaller emperature variations between morning, ay, and evening hours. The upper portions f the slope show a large amplitude of temperture variations.

The duration of the vegetation period also epends on the soil temperature. In the upper ortion of the slope the vegetation period for heat up to the beginning of waxy ripeness as 4 days less than that at the lower elenents of the slope.

An entirely different pattern of soil disribution and other conditions affecting the growth of the crops was determined for the north slope and its individual parts. The upper, highest portion of the arable slope which had a gradient of 8. 4° contained weakly eroded chernozem of average thickness, average humus and clay loam content. Some 880 m further down the slope, in a plot having a 5. 1° gradient, more eroded, southern chernozem of shallow thickness, low humus content, and having a smaller soil moisture content was found. A profile made some 1650 m further down the slope, in a location having a gradient of 1. 5°, again presents a different soil: dark chestnut soil, shallow thickness, highly eroded, with even lower soil moisture content and a more highly

Table 2

Certain properties of soils, appearance of erosion processes, and development of spring wheat in various sections of the north slope

Indicators	Soil profiles of sections of the slope		
	No. 4 upper portion	No. 5 middle portion	No. 6 lower portion
Distance downward along slope from top (m)	0	880	1650
Gradient (degrees)	8.4	5.1	1.5
Acidity of soil (pH)	6.9	7.3	7.8
Thickness of humus horizon (cm)	64	35	25
Humus (% on dry soil)	6.93	6.35	4.98
Depth of effervescence (cm)	28	20	surface
Maximum hygroscopic water (in the soil layer from 0-10 cm), %	8.05	7.51	5.85
Content of separates (%)			
>0.25 mm in diameter	20.24	33.23	48.59
0.25 —0.05 "	31.57	28.51	24.70
0.05 —0.01 "	11.41	8.31	3.00
0.01 —0.005 "	6.32	5.91	4.44
0.005—0.001 "	10.59	9.73	8.32
<0.001 "	19.67	14.31	12.95
<0.01 "	36.58	29.95	23.71
Soil temperature, °C, at depth of 5 cm (average for the period 7/13-7/18)			
at 6 hrs.	8.8	8.9	9.4
at 14 hrs.	22.0	23.3	25.1
at 20 hrs.	16.7	17.7	18.4
Mean daily temperature, °C	15.8	16.6	17.6
Total of available moisture in a 1 m soil layer (metric tons/ha)	228	169	43
Loss of soil from erosion (metric tons/ha)			
a) wind	0.31	2.43	13.45
b) water	2.11	0.75	0
Beginning of milk stage	July 22	July 19	July 15
Height of growth (cm)	74.3	53.5	41.2
Total stalks (no/m²)	415	375	325
Productive stalks (no/m²)	391	316	217
Yield (cntr/ha)	23.5	19.8	14.7

alkaline reaction.

In the upper portion of the north slope the content of fine separates was more noticeable. On proceeding down the slope, the content of coarse separates (particles with a diameter of 1-0.25 mm) increases, while the quantity of the finer particles decreases. The north slope receives less heat than the south slope. The temperature amplitudes to which soils of the upper slope are exposed during the course of the day are less strong than those affecting the south slope. Average daily temperatures of the upper portions of the slope are lower (by 0.6-1.8° C) than those of the lower portions. Variations in temperature conditions of the soil of the given slope appeared to be less pronounced than those affecting soils in other experiments.

The vegetation period of wheat on the north slope turned out to be 3-6 days longer than that on the south slope. The period of vegetative growth in the upper portions of the given slope appeared to be 7 days longer than that on the lower elements of the slope. Thus, erosion phenomena play an exceedingly important role in soil formation, affecting the growth, development and yield of crops as well as the cost of the agricultural products obtained.

Wind and water erosion over many decades roduced conditions such that more than half f the territory of the Dzerzhinskiy kolkhoz apeared to have been affected by erosion procsses to a greater or lesser degree.

Each year soil erosion results in heavy maerial losses to the economy. Group yield is educed: in weakly eroded soils, by 11%-21%; soils subjected to medium erosion, by 20%-9%; and in greatly eroded soils, by more than alf compared with normal development of oils not affected by erosion processes.

The intense erosion processes in the tertory under investigation were helped along y such natural factors as typical erosion topgraphy (nearly 80% of the kolkhoz lands have a radient of more than 2° and there is an ingnificant quantity of precipitation — 273-325 m per year), the extreme dryness of the air d the soil, lack of humus, shallow soil, deep eezing of the soil, and weak soil structure.

Particularly dangerous and damaging to e territory under investigation is wind eroon. The predominant winds here are from e southwest and west. Wind velocity, on e average, is 2.6-3.2 m/sec, but, at times, d particularly during the spring and summer, ind velocity reaches 20-25 m/sec. In such ses, action of the wind on the soil is intensied by dust storms.

Thus, for example, early in the spring of 57, after the spring wheat had been planted, e observed a dust storm of 10-12 days' duraon which blew away an average of 13 metric ns of soil/ha; in certain sections 3-5 cm of e upper soil layer was removed. Wind eroon would result if the soil surface had not een protected by vegetation.

As shown in the previous data (Tables 1 d 2), the lower elements of the north slope e subjected to the most intense blowing hich is primarily a result of the increased nd velocity and the unfavorable soil moisre condition. The upper elements of the rth slope carry relatively infrequent traces wind erosion; this is explained by their more otected location, and also by more favorable ter and other soil property conditions which rve to improve ability to withstand erosion.

In the steppe regions of the Minusinsk deession wind erosion appears to be strongest the west, south, and southwest slopes; this owing to their open location and to the less vorable soil moisture conditions. The inence of the wind on the soil is directly reted to texture, structure, cover crops, and any other factors.

It should be noted with respect to the south pe that its upper portion contains gravelly-sandy loam soils. As a result of the continued action of the wind, and also the erosion caused by atmospheric precipitation, the quantity of silty material is smallest here (Table 1). However, wind erosion is quite intense here. The latter circumstance is explained by the complete absence of a snow cover during the winter period, by exceedingly dry soil, as well as the triple, intense cultivating of the upper layer of the soil. After planting, the dry, easily pulverized soil is subject to deflation.

In the lower portion of the south slope, the wind action appeared to be less significant. This results from reduced wind velocity and more favorable soil moisture conditions: from the beginning of spring operations to wheat germination, the surface layers of the soil are exposed to moisture.

The year 1957 was a comparatively dry year: between April and the latter part of July there was only half of the normal amount of precipitation. Because of the small amount of precipitation, no surface run-off and, consequently, no water erosion was observed by us on the slopes under examination. Even on the upper, steeper portion of the south slope (9.6°), no wash-outs or scouring were observed. This was governed primarily by the presence here of microskeletal soils developed as a result of eluviation and illuviation. However, during periods of strong rainfall, these soils too were subjected to water erosion.

Confirmation of the foregoing can be found in the data in Tables 1 and 2 concerning the surface run-off resulting from the rain on July 17, 1957. Magnitude of water erosion (as can be seen from the given data) increases considerably (9.32 metric tons/ha), even in the gravelly-sandy loam soils of the upper portion of the south slope which has high water permeability. Evidently the steep slopes, the lack of soil protection by vegetation, and the high intensity of the precipitation (0.8 mm/min) were the principal factors of water erosion that helped increase surface run-off of rain water and soil wash-out.

The foregoing data on water erosion of the soil in four sections of the south and north slopes do not attempt to reduce the significance of texture as an important factor in erosion. This is evidenced by the fact that rain eroded 28 metric tons of soil/ha from a plot of leached clay loam chernozem plowland, operated by the first brigade on a slope with 4° gradient.

CONCLUSIONS

1. On the territory of the Dzerzhinskiy, the Bogradsk, and adjacent rayons of the Minusinsk depression, the local topography exerts significant influence on the distribution of soils, the intensity of erosion processes, and conditions for crop growth.

2. The character of such changes varies with different slopes and individual elements of such slopes. As observed in the sections of the south slopes, the most notable changes in the soil are caused by topography and erosion processes.

3. Most affected by wind erosion are the exposed upper elements of the south and southwest slopes and dry, highly pulverized, low-fertility soils.

4. Fields located on steep slopes, relatively unprotected by vegetation, and soils having other poor physical properties, also are subject to water erosion which is particularly intense during the period of strong rains.

5. The data indicate the need for a different approach to the evaluation and utilization of soils; allowance should be made for the exposure of slopes, their gradient, location of fields on a slope, moisture, temperature, and other soil conditions, as well as erosion processes.

6. Determination of suitable agricultural methods must take into account a number of measures designed to protect the soil against erosion and to increase the fertility of eroded soils.

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MOBILITY OF COMPOUNDS OF COBALT, STRONTIUM, AND CESIUM IN THE SOIL

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The question of the mobility of microamounts of elements in the soil is closely related to several problems; one of which is V. I. Vernadskiy's principle of the migration of chemical elements and their accumulation or distribution in certain sections of the biosphere. Secondly, it is related to the problem of microelements, currently of great theoretical and practical significance. The varied mobility of elements determines the fate of microelement fertilizers that are introduced into the soil, their eluviation from or their establishment in the soil. Finally, the question of the mobility of microamounts of elements is particularly interesting in connection with the contamination of the soil and vegetation by radioactive contaminants.

The mobility of elements is determined by the chemical properties of compounds which these elements help to make up, the solubility of compounds, the character of adsorption of the elements by the soil and the strength of their bond with the soil. The dependence of element mobility on the chemical stability in the liberation zone of those minerals which they help to make up, has been thoroughly studied in geochemistry and many papers have been devoted to this question (2, 4, 5, 8). Studies have been made of the mobility of such cations as Ca^{++}, Mg^{++}, Na^{+}, and K^{+}, related to the varied stability of the sorption of these cations by the soils (1, 3, 6, 10).

Investigations devoted to the study of sorption by the soil of microamounts of scattered and rare elements, the strength of sorption and the mobility of these elements depending upon it have been little published. Research in this area is of unquestionable interest, and the conduct of such investigations is simplified at present by the use of the tagged atoms.

We conducted an experiment designed to determine the mobility of strontium, cobalt, and cesium in the soil. The literature contains certain information with respect to these elements. Strontium, apparently, has the greatest mobility. Given a strontium-90 content in the soil, it was found that it penetrates to a depth of 70 cm (9). Investigators relate this to the great solubility of strontium salts. The penetration of soil by cesium-137 is limited to the upper layer (7). Experiments conducted with cesium-137 have shown that the soil irreversibly adsorbs a certain quantity of cesium (11). Such adsorption was also observed for cobalt which is explained by the fact that a portion of the cobalt passes into a trivalent state and remains in the soil in the form of hydroxides or complex compounds (12, 13).

Material and Methods

The work was carried out with the help of radioactive isotopes: cobalt-60, strontium-90, and cesium-137, which were taken in indicator quantities without addition of carriers. Activity of the solution used in the experiment was as follows: cobalt-60 — 20 μCu/l, strontium-90 — 4 μCu/l, cesium-137 — 10 μCu/l. The soil under investigation was plow layer chernozem of the Il'men National Forest, Southern Urals; pH of the soil was 7.8, and content of exchangeable calcium 30.5 meq and that of exchangeable magnesium was 14.3 meq/100 g of soil. Experiments were carried out under dynamic and static conditions. In the dynamic experiment, glass tubes 1 cm in diameter and 18 cm long, with a volume of 16 cc were filled with the soil under examination; weight of the soil sample was 12 g, volume of the soil filter was 12 cc, length was 15 cm. Solutions were added into the glass tube from below, from large containers located approximately 1 m above the opening of the glass column. The speed of filtration was approximately 0.5 ml per minute. Volume of the filtrate was measured in volume of the soil filter (12 cc). At intervals 15-20 volume samples were taken to measure activity of the filtrate. Tests for sorption and desorption were conducted with the aid of soil filters.

Sorption of the cobalt, strontium, and cesium was carried out with the aid of filtered lake water (pH of the water — 7.8, content of Ca — 26, Mg - 9.5, and Na + K — 9 mg/l. During desorption, calcium nitrate was added to the water so that the desorbing solution contained Ca - 250, Mg - 9.5, Na + K — 9 mg/l).

Based on the number of elements, the experiment consisted of three series; for each of these four columns were used. About 120 volumes of the solution, containing the element under investigation, were passed through the columns. One of the four columns in each series was subjected to analysis, while a desorbing solution was passed through the other three. In the cobalt and cesium series, 150 volumes were passed through the second column, 350 through the third, and 600 through the fourth column of the desorbing solution. In the strontium series, 30 volumes were passed through the second column, 150 through the third, and 350 through the fourth. After completion of the experiment the filters were separated into five vertical layers, 3 cm long and weighing 2.2-2.6 g. The soil in each layer was dried, thoroughly mixed, and samples were then taken to determine activity concentrated in the given layer.

In the static experiment soil fractions smaller than 1 mm in diameter were used. Amounts of soil weighing 1 g and a volume of 40 ml of the solution under investigation were placed in plexiglass test tubes equipped with screw caps and the components were mixed with the aid of an electric mixer until equilibrium was established between the soil and the solution. After mixing, the solution was centrifuged from the soil, and samples were taken from it for determination of activity. Activity, adsorbed by the soil, was determined by measuring the activity of the initial solution and that of the centrifuged solution. Activity measurements of strontium were conducted after a radioactive equilibrium had been reached between the strontium and its related product, yttrium. All measurements were conducted with the aid of a radiometer of type "B" equipped with a surface or horizontal tube.

Samples were collected in aluminum cups having a diameter of 2 cm; volume of the liquid sample was 1 ml, weight of soil samples for weakly active layers was approximately 100 mg, and that of the more strongly active layers was approximately 10 mg. In activity measurements of cesium-137, and cobalt-60 in the soil samples, corrections were made for self absorption in the sample. The error in activity measurement of samples did not exceed 3%.

Results

Given in Table 1 are results of dynamic experiments of the sorption, through soil filters, of microamounts of cobalt, strontium, and cesium from lake water. Data in the table indicate that the percentage of cesium and cobalt passed through the experiment remains nearly constant, varying around an average magnitude, while the percentage of strontium that has passed into the filtrate increases in direct proportion to the increase in number of volumes of solution passed through the soil. The general amount of activity that has passed into the filtrate is expressed in percentage of activity of the initial solution, and after passin 120 volumes, equals 0.4% for cesium, 3.4% for cobalt, and 9.5% for strontium.

Table 1

Relation of activity on number of volumes of solution passed through[a]

No. of volumes of solution passed through	Activities of solutions passed through[a]		
	Cobalt	Strontium	Cesium
20	2.7	0.2	0.8
40	3.8	1.0	0.2
60	4.2	2.7	0.5
80	2.0	4.3	0.4
100	3.3	7.2	0.2
120	3.4	9.5	0.4

[a] Activity of solution passed through is given as a % of the initial solution

Table 2 shows the distribution of each element in the soil filter, determined by measurements of the activity concentrated in each of th five vertical layers into which the filter had been divided. As can be seen from the table, the strontium content in successive layers of the soil filter increases more or less uniformly and, in the last layer, amounts to 1.65% of total activity; the cobalt is concentrated primarily in the first two layers and, in the last layer, amounts to only 0.45%; the cesium is sorbed almost entirely by the first layers, and, in the last layer, it amounts to only 0.05% of total activity.

To compare the strength of sorption by the soil, of cesium, cobalt, and strontium (as discussed previously in the description of the method), we conducted experiments for the desorption of these elements from soil filters by a solution obtained by means of adding to lake water a quantity of calcium nitrate of a composition close to that of the

Table 2

Distribution of activities by layers of soil filters[a]

Layer	Activity in each 3cm layer[a]		
	Cesium	Cobalt	Strontium
1[b]	95.20	86.30	48.00
2	4.22	11.10	27.12
3	0.45	1.50	18.08
4	0.08	0.62	5.15
5	0.05	0.48	1.65

[a] Activity, concentrated in each layer is expressed as a % of the activity adsorbed by the whole filter.

[b] The first layer is that nearest to the point of entry of the solution into the column.

Table 3

Relationship of percentage of desorption on number of volumes of desorbing solution

No. of volumes of desorbing sol- passed thru.	Desorbed activity[a]		
	Cobalt	Strontium	Cesium
40	0.1	55	0
80	0.3	82	0
120	0.5	88	0
160	0.7	95	0
200	0.9	96	0
240	1.1	97	0
280	1.3	98	0
320	1.5	99	0

[a] Desorbed activity is expressed as a % of activity, adsorbed by the filter.

verage composition of the soil solution. Re-
ults of the experiments shown in Table 3 indi-
ate that under these conditions strontium is
lesorbed quickly and easily from the soil;
fter some 30 volumes of the solution have
een passed through the filter, some 40% of
he activity is desorbed; the speed of desorp-
ion is then reduced; however, desorption con-
inues and after 320 volumes of the solution
ave been passed through the filter, strontium
s desorbed almost completely. Cobalt is
lso desorbed but in insignificant quantities;
fter 320 volumes of the solution were passed,
nly 1.5% of its activity, concentrated in the
oil filter, was desorbed. Finally, under
imilar conditions, cesium does not desorb
t all.

An analysis of the distribution of activity
y layers of the soil filter, made after 150, 300, and 600 volumes of the desorbing solutions have been passed through the filters, indicated that there was some displacement of activity by filters on the part of cobalt and cesium; however, the results obtained were not adequate for a quantitive determination of the displacement. As before, the last layer of each filter in the cobalt series showed activity not in excess of tenths of a percent for cobalt, while in the cesium series the activity did not exceed hundredths of a percent.

Entirely different results were obtained in the experiments with strontium. Figure 1 shows the redistribution of the strontium by layers of the soil filter obtained in the desorption process. As noted previously, after some 30 volumes of the desorbing solution had been passed through the filter, approximately 38% of the total activity concentrated in the filter passed into solution. The balance of the activity was distributed uniformly over the entire filter. The uniform distribution of the activity did not change even after 150 volumes of the desorpting solution had been passed; only 7% of the activity remained in the filter.

Having determined the differences in the sorption of cesium, cobalt, and strontium in the soil under investigation, we conducted a number of static experiments to determine the influence of extraneous cations on the sorption of cobalt and cesium. First, we determined the time necessary to establish equilibrium for the process of sorption of cesium from a solution of potassium nitrate having a concentration of 100 meq/l and also of cobalt from a solution of calcium nitrate of the same concentration. These solutions were selected on the basis of preliminary experiments that showed the influence of potassium ions on the sorption of cesium and the influence of calcium ions on the sorption of cobalt. Data obtained in the experiment for the establishment of equilibrium are shown in Table 4. As can be seen from the table, the element under investigation reaches a state of equilibrium after 20 minutes in a system "soil-nitrate solution." All subsequent experiments were conducted under equilibrium conditions.

The first series of experiments established the influence of ions of sodium, potassium, magnesium, and calcium (i. e. all the cations that make up the soil solution and the soil sorption complex) on the sorption of cesium by the soil under investigation. The concentration of cations was varied from 0-500 meq/l. Results of the experiments are given in Figure 2 which shows that ions of sodium, magnesium, and calcium, in concentrations in effect during the interval under investigation, exerts no influence on the sorption of cesium; sorption in all cases reaches 99%. Of all the cations

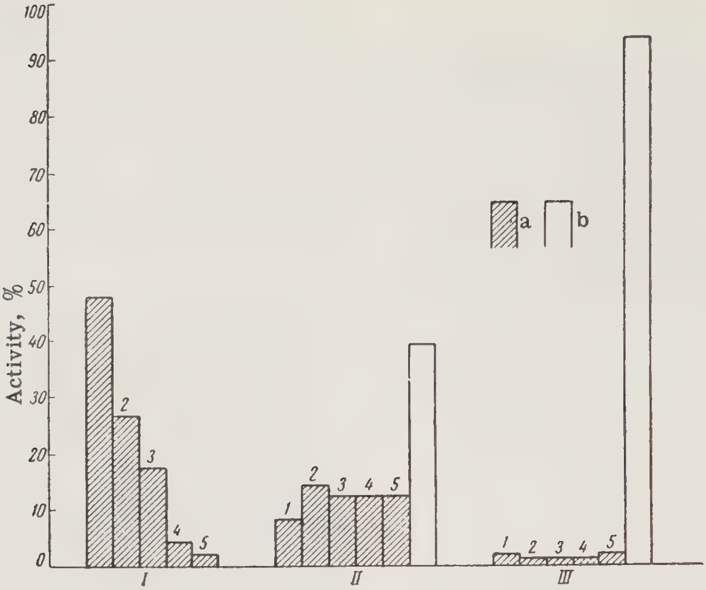

Fig. 1. - Dynamic experiment of strontium distribution in the soil filter.

a - activity in layers of the soil filter, thickness of layer - 3 cm. First column represents the layer nearest to the point at which solution enters the column; b - desorbed activity.

I - distribution of strontium by layers of the soil filter prior to desorption; II - distribution of strontium by layers of the soil filter after 30 volumes of the desorbing solution were passed through the filter; III - distribution of strontium by layers of the soil filter after 150 volumes of the desorbing solution were passed through the filter.

Table 4

Determination of percent of sorption of elements in systems: soil—calcium nitrate solution—cobalt; soil—potassium nitrate solution—cesium[a]

Duration of mixing	% of sorption	
	Cobalt	Cesium
20 min.	87.0	86.2
1 hr.	89.2	83.9
2 hrs.	88.1	84.0
4 hrs.	87.5	85.2
Average	87.9	84.8

[a] Weight of soil sample — 1 g, solution volume — 40 ml. Durations of mixing of soil with solution varied.

studied, only potassium reduces cesium sorption in direct proportion to the quantity of potassium in solution.

The second series of experiments was designed to study the influence of the same cations on the sorption of cobalt by the soil. As can be seen from the data in Figure 3, sodium and potassium showed no influence on the sorption of cobalt, however, calcium and magnesium reduced the percentage of sorption, with the influence of calcium being expressed more strongly. Thus, the static experiments indicated the relationships of sorption of cesium by the soil on the presence, in the solution, of potassium ions and the relationships of cobalt sorption on the presence, in the solution, of calcium and magnesium ions.

Conclusions

Dynamic experiments were conducted to study the sorption and desorption of microamounts of cobalt, strontium, and cesium by the soil under investigation; these experiments showed that strontium is the most mobile of these elements. During sorption

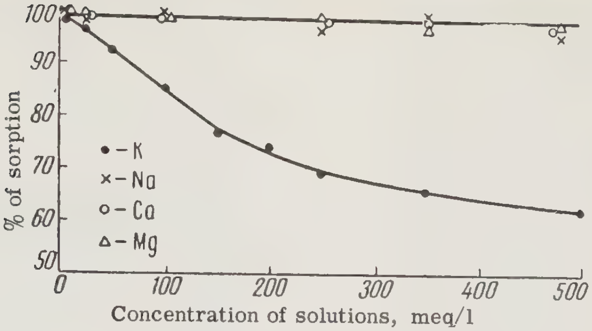

Fig. 2. - Static tests for sorption of cesium by the soil from solutions of KNO_3, $NaNO_3$, $Mg(NO_3)_2$, and $Ca(NO_3)_2$ at concentrations ranging from 0 to 500 meq/l. Weight of soil sample - 1 g, solution volume - 40 ml.

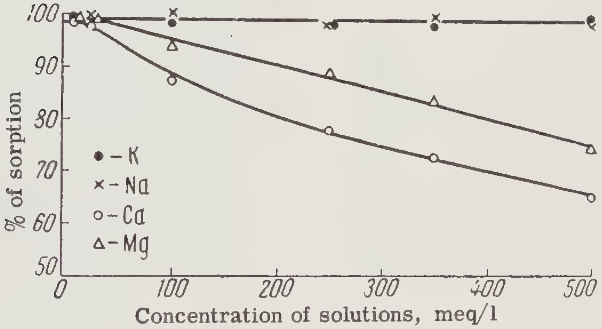

Fig. 3. - Static experiments for sorption of cobalt by the soil from solutions of KNO_3, $NaNO_3$, $Mg(NO_3)_2$, and $Ca(NO_3)_2$ in concentrations ranging from 0-500 meq/l. Weight of soil sample - 1 g, solution volume - 40 ml.

from a solution with soil filters, strontium most rapidly passes into the filtrate, and the percentage that passes into the filtrate increases with the increase in the number of volumes of solution passed. Strontium is easily leached and can be fully desorbed by the soil. The study of the distribution of strontium in the filter after sorption and after desorption, as well as the data obtained earlier, indicate that this element maintained good mobility in the soil as a result of exchange reactions. It is adsorbed by the inactive layer of the soil, desorbed from there in the solution and sorbed anew by the next inactive layer. In this manner, strontium, during desorption, is quite uniformly distributed over the soil filter; its movement in the soil is not limited to a band, but is continuous.

Microamounts of cobalt and cesium are considerably less mobile, with the low mobility being peculiar to cesium. While, in our experiments, cobalt passed into the filtrate to the extent of 3 to 4% during sorption and during desorption was leached even though to a very small extent, cesium appeared in the filtrate during sorption only to the extent of 0.5%, and was not desorbed at all. The results of the static experiments confirm the results of the dynamic experiments. Sorption of cesium is influenced only by potassium; the potassium content in solution during the dynamic experiment did not exceed 0.1 meq/l. Sorption of cobalt is reduced by calcium and magnesium cations; their general content in solution from which cobalt was sorbed during the dynamic experiments reached 2.1 meq/l. This probably explains the high mobility of cobalt, as compared to that of cesium, determined in our experiments.

Thus, it was determined in static experiments that sorption of cesium by the soil is specifically affected by potassium, while sorption of cobalt is influenced by calcium and magnesium. This fact evidently indicates that during sorption of cesium and cobalt by the soil, nonsoluble compounds of these elements are formed. Potassium is an element that is very close to cesium in its chemical properties and it can form the same compounds in the soil as cesium; however, compounds formed by potassium are more easily soluble. When large quantities of both are present in solutions, potassium probably competes with cesium during the formation of these nonsoluble compounds and serves to reduce cesium absorption by the soil. The same assumption may be made with respect to systems: soil — calcium salt solution-cobalt, and soil — magnesium salt solution-cobalt. Thus, only assumptions may be made about the uptake by the soil of microamounts of cobalt and cesium; these assumptions still require proof.

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EFFECT OF SOIL SALINITY ON GROWTH OF OAK AND OTHER SPECIES UNDER IRRIGATED CONDITIONS IN AZERBAYDZHAN SSR

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Azerbaydzhan is one of the principal cotton-producing territories of the USSR. Its irrigated zones are non-forested. At the present time considerable work is being done to introduce protective planting in cotton fields, pastures, along roads, canals, and near settlements. The irrigated land zone is characterized by a great variety of forest growth conditions. A detailed study of existing protective plantings has shown that forestation of fields in Azerbaydzhan SSR is complicated by salinity of the soil and existence of ground water. This is explained by the fact that a majority of the trees and shrubs, which are glycophytes, react negatively to an increased content in the soil of water-soluble salts.

Efforts, extending over many years, by Kovda (14, 15, 16), Kachinskiy (10), Antipov-Karatayev (1), and other investigators, helped to determine that the presence of excess water-soluble salts affects the soil's hydrophysical properties and, as a result, plant growth and productivity are considerably reduced. In their study of the growth and development of herbaceous plants (halophytes and glycophytes), several investigators (4, 5, 11, 12, 13, 19, 20, and others) came to the conclusion that the considerable salt tolerance of halophytes can be explained by the high osmotic pressure of the cell sap which sometimes reaches 100-200 atm in leaves. This facilitates water absorption from saline soil solutions by the root system. In addition, halophytes are capable of controlling internal osmotic pressure, of throwing off leaves that have too high a salt content, and of preventing salt from entering cell tissue, as a result of comparatively low salt permeation. Of the plasma; they also have the ability to close the stoma and reduce to zero the intensity of transpiration when there is a great excess of salt in the soil solution.

The opposite is observed with respect to glycophytes: salinity of the soil has a negative effect on their water content, assimilation, and other important processes.

The question of salt tolerance on the part of various trees and shrubs was dealt with by Vysotskiy (2, 3), Morozov (18), Kossovich (17), Stepanov (21, 22), Grigor'ev (6), Khrenov (23), Yakubov (25), Zhemchuzhnikov (7, 8, 9), Shakhov (24), and many others. It was determined that when water-soluble salt content in the soil reaches 0.5%, most trees are subject to injury, while only very few can withstand the effect of a 1% water-soluble salt content (date palm, haloxylon, tamarisk, and oleaster). A Cl content of up to 0.05% and an SO_4 content in excess of 0.25% constitute the limit for most species. The most injurious action, within the limits of 0.05% and 0.25%, is caused by sodium. In the opinion of the majority of the investigators, gypsum is harmless. The effect of character and degree of soil salinity on development of trees and shrubs have not been sufficiently studied in relation to irrigated forest conditions; obviously, this question is currently of great interest.

To determine the effect of the degree of soil-salinity on the growth of oak, walnut, persimmon, pine, the European plane tree, and other tree-shrubs, we planted, in the period from 1951 to 1956, a number of special test plots on strips of forest land and in irrigated zone nurseries; we also conducted special pot experiments with various species of oak. The experiments considered: the care of seedlings, their growth in terms of both height and diameter, quantity of leaves, crown dimensions, dry weight of the seedlings, depth of root penetration into the soil, root structure and distribution, as well as salt content in the leaves, stalks, and tops of the trees under investigation. On each plot, determinations were made of HCO_3, Cl, SO_4 and of solid residue based on the soil horizons.

The experiments have shown that, in irrigated soils of average salinity (solid residue 0.55%), in spite of six irrigations, the height, diameter and other indexes of walnut, persimmon, and ash seedlings were 1 1/2-2 times smaller than those in weakly saline soils (solid residue 0. 20%). In sierozem soils in which the salt concentration varies from 0. 50%-0. 66%, with four irrigations, large numbers of year-old seedlings of apricot were lost, while honey locust did not seem to suffer at all. With salt concentrations ranging from 0. 60%-1. 08%, the growth of oak and plums declined. Amorpha seedlings grew satisfactorily with salt concentrations ranging from 0. 20%-0. 43%; however, under conditions of strong salinity (1. 8%), they died. The majority of plant roots, having reached the saline horizons, stopped growing and died (Fig. 1), while some rootlets, upon reaching strongly saline horizons, turned to one side or another and continued to grow horizontally (Fig. 2).

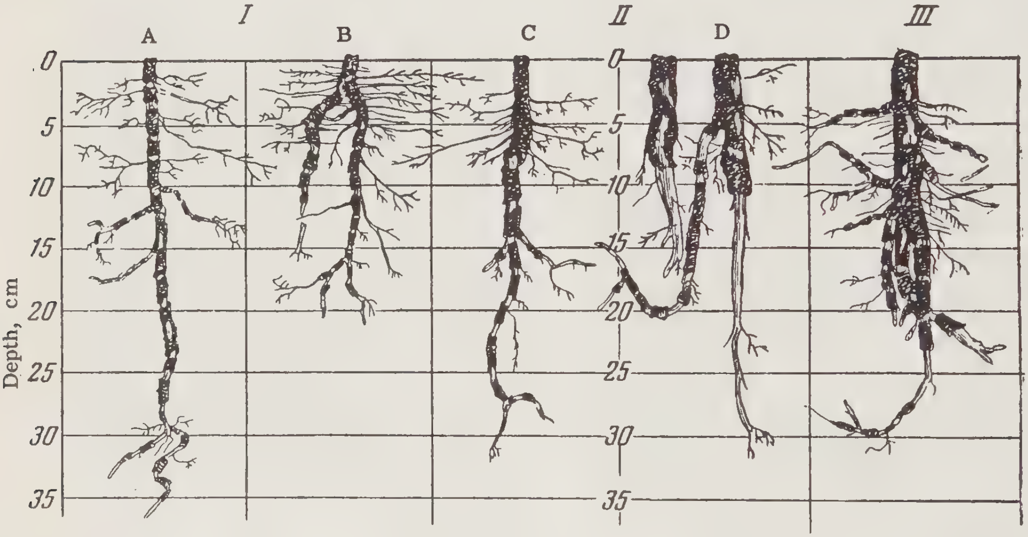

Fig. 1. - Scaling of crust from roots of dried-up seedlings of various arboreal species under conditions of excess soil salinity.

I. a - year-old long-stalk oak and b - two-year-old apricot, growing in highly-saline medium-clay-loam solonchak soils (solid residue 1.420%). II. c - year-old plum and d - two-year-old amorpha, growing in highly-saline typical sierozems of the Mil'sk steppe (solid residue 1.8%). III. Three-year-old chestnut oak, growing in meadow-sod sierozems of medium salinity in the Mugansk steppe.

The increased salt content in the soil negatively affects the growth and development of trees in more advanced stages of development. With four to five annual irrigations, a three-year growth of long-stalk oak, planted on the wooded strip of the Mil'sko-Shirvansk experimental plot on typical sierozems of average salinity (solid residue 0. 37%) appeared to be 1 1/2-2 times less developed in terms of height, diameter, and other growth indexes, than growths on weakly saline sierozems (solid residue 0. 111%). If, on weakly saline sierozems, oak seedlings reached a height of 160 cm and an average diameter at the root neck of 16 mm, the corresponding dimensions, on sierozem of average salinity, were 97. 5 cm and 8 mm. In weakly saline sierozem, the number of leaves on one oak was 803, compared with 105 on a tree planted in sierozem of average salinity.

In saline sierozem, the roots of the oak seedlings penetrated to a depth of 96 cm while, in weakly saline sierozem, they reached a depth of 160 cm; the weight of the roots in dry condition, in saline soils, was 35. 6 g and, in weakly saline sierozem, 69. 4 g. Most of the oak roots (85. 3%), in saline sierozem, was concentrated in the 0-25 cm layer and, in weakly saline soils, the roots were distributed more uniformly throughout the root layer. The distress of the oaks, their drying and wilting were evidently a result of the fact that the quantity of chlorine ions in medium saline soil varies from 0. 058%-0. 111%, while, in weakly saline soil, their content is merely 0. 015%-0. 019%. Thus, in weakly saline soils, the loss of oaks constituted 23. 8%, and, in medium saline soils, 82. 5%.

Excess salinity negatively affects the growth of irrigated stands of three-year old chestnut oak. Growth and development of the oak in protected forest strip No. 12, planted in meadow-sod soil of varying salinity, is described by

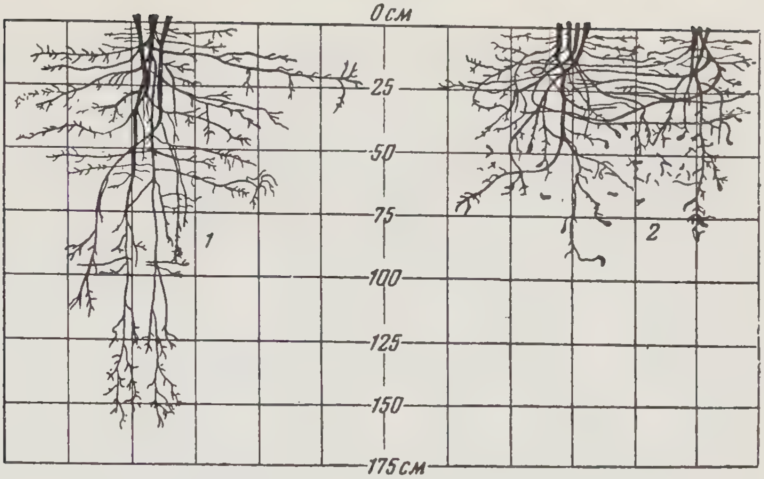

Fig. 2. - Morphological structure and depth of penetration of the root systems of three-year-old chestnut oak in weakly saline (1) and medium saline (2) irrigated meadow-sod sierozems.

Table 1

Comparison of characteristics and growth of three-year-old irrigated stands of chestnut oak in weakly- and medium-saline meadow-sod sierozems of northern Mugan

Index	Soil salinity, % of solid residue	
	Weak (0.178)	Medium (0.782)
No. of clumps with oak plants (%)	84.40	38.52
No. of oaks per clump (each)	17.1	6.0
Same, but per ha (1000's)	9.814	1.541
Average height, cm	237.2	140.2
Average diameter of trunk at neck of root, mm	33.1	18.4
Dimension of crown, cm (longitudinal)	211.0	76.5
Dimension of crown, cm (across)	192.0	84.1
Total leaf surface area of oaks per ha (m^2)	12219	357
No. of dead oak trees, %	32.40	94.70
No. of oak trees measured (each)	849	626

Note: Both plots, over a three-year period, received 15 irrigations.

data shown in Table 1. Excavations and the study of root systems (Table 2) showed that, in weakly saline sierozems, the mass of oak roots is more than three times larger than that of oak growing in sierozems of medium salinity. The principal mass of the roots in the weakly saline soils is in a 150 cm layer of soil; in soils of medium salinity, the roots are in the 0-50 cm layer; in saline soils with a salt content of 0.612%-0.936%, the fine rootlets (having a diameter of less than 1 mm) and even the coarse ones (having a diameter of more than 1 mm) are dead and decompose.

The main reason for the poor development and destruction of roots in saline soils must be the high concentration of chlorides (0.34%-0.97%) and sulfates (0.34%-0.43%). The high concentration of salts reduces growth and survival of other trees. In flood-plain forests of coarse clay-loam soils of medium salinity (solid residue 0.49%-0.90%) a year-old Euro-

Table 2

Distribution of roots in three-year-old seedlings of chestnut oak in relation to the degree of salinity of meadow-sod sierozems of northern Mugan

Depth, cm	Weakly saline meadow-sod sierozems						Medium saline meadow-sod sierozems					
	Salt content in % of dry soil				Root weight, g		Salt content in % of dry soil				Root weight, g	
	HCO_3^-	Cl^-	$SO_4^=$	Solid residue	Total	Fine roots	HCO	Cl	SO	Solid residue	Total	Fine roots
0—10	0,055	0,021	—	0,16	8,92	2,48	0,076	0,013	0,049	0,29	2,56	1,20
10—25	0,048	0,019	—	0,12	13,10	2,08	0,069	0,013	0,259	0,34	2,76	1,84
25—50	0,036	0,017	—	1,10	11,64	2,60	0,046	0,034	0,341	0,61	4,20[a]	2,80[a]
50—75	0,046	0,018	0,026	0,11	6,72	1,52	0,046	0,097	0,352	0,69	2,80[b]	1,36[b]
175—100	0,046	0,014	0,017	0,18	5,44	1,48	0,031	0,064	0,439	0,79	1,92[b]	1,08[b]
100—125	0,031	0,013	0,079	0,26	4,24	1,36	0,034	0,178	0,369	0,94	3,44[b]	1,96[b]
125—150	0,038	0,013	0,030	0,27	3,72	1,16	0,057	0,108	0,539	1,13	—	—
150—175	0,031	0,015	0,035	0,21	3,44	1,12	0,046	0,307	0,582	1,47	—	—
175—200	—	—	—	—	2,00	1,44	—	—	—	—	—	—
200—225	—	—	—	—	2,08	1,20	—	—	—	—	—	—
225—250	—	—	—	—	1,92	1,92	—	—	—	—	—	—
Total					63,32 100%	18,34 28,96%					17,68 100%	10,24 57,91

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[a] Partial dying of oak rootlets.

[b] All rootlets died.

Note: Comma represents decimal point.

pean plane tree had an average height of 33.6 cm while, in weakly saline soils (solid residue 0.16%-0.27%), the height was 69 cm. Their diameters were 3.7 mm and 7.4 mm and the weight of their roots was 10.85 g and 20.05 g, respectively.

If, in weakly saline soils, a two-year-old European plane tree had a height of 250 cm, a diameter of 26.9 mm, and an average of 31 leaves per tree, a saline soil environment reduced these indexes to 114 cm, 12.8 mm, and 23 leaves. These data are summarized in Table 3.

Excess salinity of soils also has a negative effect on the survival and growth of white acacia. This was evidenced by the dried up stand on medium-saline flood-plain forest soils in the Soyugbulaksk forest reserve of the Akstafinsk leskhoz (Table 4). Table 5 contains data on the salinity of these soils.

The study of the acacia root system (Fig. 3) resulted in the following: 1) The general mass of roots of an eighteen-year-old acacia in weakly saline soil is three times larger than that of a plant in medium saline soil and, under conditions of excess salinity of the soil, 17.07% of the roots died and decomposed. The number of skeletal roots (with a diameter larger than 3 mm) in weakly saline soils is 3 1/2 times, that of conducting roots (having a diameter of 1-3 mm) is 4 1/10 times, and that of suctorial roots (<1 mm in diameter) is 3 1/2 times larger than the number of roots in soils of medium salinity; 2) If in weakly saline soils (solid residue of a 2 m layer is 0.26%) the principal mass of suctorial roots (94.57%) is concentrated in the 0-100 cm layer, the roots in soils of medium salinity are distributed over a layer of 25 cm where the content of water-soluble salts, based on solid residue, does not exceed 0.15%-0.24%; (3) When soil salinity increases to 0.48%-1.36% and particularly, when chloride concentration increases to 0.03%-0.14%, both the large and the fine roots die and are decomposed.

Under saline soil conditions (as indicated by anatomic research), thicknesses of the cell walls of the primary roots, pericycle, and the conducting vessels, as well as that of the external layer of the sample, is 1 1/2 to three times larger than those in weakly saline soils. In saline soil horizons (solid residue 0.4%-0.9%) destruction of parenchymatous cells in whole sections took place and, the more saline the soil, the more spots with dead and decomposed cells were found.

Table 3

Comparison between growths of various trees of six-year-old stands in irrigated meadow-sod sierozems of various salinity

Name of species	Average height, m		Average diameters, cm			
			At nect of root		At breast height	
	0,109	0,473	0,109	0,473	0,109	0,473
Poplar (Lombardy)	9,20	4,20	12,50	5,10	9,20	2,60
Maple	5,30	3,25	8,50	5,70	4,45	2,80
Japanese sophora	3,60	2,80	5,25	4,20	3,00	2,20
Green ash	4,60	3,40	5,40	4,60	3,60	2,95
Western catalpa	4,35	3,50	5,40	4,30	3,80	2,50
Quince	4,60	3,40	9.90	6,50	2,70	2,40
Plum	3,30	3,26	5,30	5,40	2,80	2,90

Note: 1. In the second half-meter of a plot of medium salinity, solid residue reaches 1.39, and in the third, 0.90%, with chlorides predominating to the extent of 0.03%-0.18%.

2. On a plot of weakly saline soil, solid residue in the second and third half-meter do not exceed 0.15%, with chlorides constituting only 0.03%.

Note: Comma represents decimal point.

Table 4

Survival of trees and growth of an 18-year old white acacia on irrigated soils of varied salinity

Index	Degree of soil salinity, based on solid residue, %	
	Weak (0.251)	Average (0.840)
Survival of trees per ha, %	81,7	
Average height, m	11,3	4,5
Average diameter at breast height, cm	9,5	4,4
Trunk volume, (cm^3)	0,34	0,07
Volume of roots as % of total trunk volume	18,9	35,4
Weight of roots in air-dried condition >1 mm in diameter, g	2216,92	695,36
Weight of roots in air-dried condition <1 mm in diameter, g	461,16	173,72
Dimensions of crown along and across rows, m	3,35—3,64	0,74—0,75
Weight of leaves of one tree, kg	2,267	0,329
Total leaf surface area per ha, m^2	46671	2604
Weight of seeds of one tree of average development, g	29,3	11,9

Note: In the first 5 years, both plots were irrigated five times per year; thereafter, one or two times per year.

Note: Comma represents decimal point.

In our study of the growth and development of the chestnut oak with relation to texture and salinity of sierozem soils (pot experiments of 1953 and 1954) we came to analogous conclusions (Table 6). Moreover, the investigations determined that the reason for the distress and dead tree seedlings in saline soils is the significant (3 1/2 times) reduction in their water

Table 5

Comparison of salinity of flood-plain forest soils with a stand of 18-year-old white acacia

Depth, cm	Salt content in % based on solid residue					
	Soils					
	Weakly saline			Medium saline		
	Solid residue	Cl	SO_4	Solid residue	Cl	SO_4
0—10	0,158	0,004	Trace	0,240	0,023	0,016
10—25	0,226	0,0	0,037	0,146	0,013	0,012
25—50	0,274	0,012	0,053	0,480	0,030	0,274
50—75	0,296	0,009	Trace	0,976	0,050	0,154
75—100	0,279	0,009	»	1,014	0,048	0,612
100—125	0,256	0,009	»	1,360	0,133	0,650
125—150	0,246	0,018	0,062	1,162	0,130	0,660
150—200	0,324	0,023	0,143	1,244	0,136	0,686

Note: Comma represents decimal point.

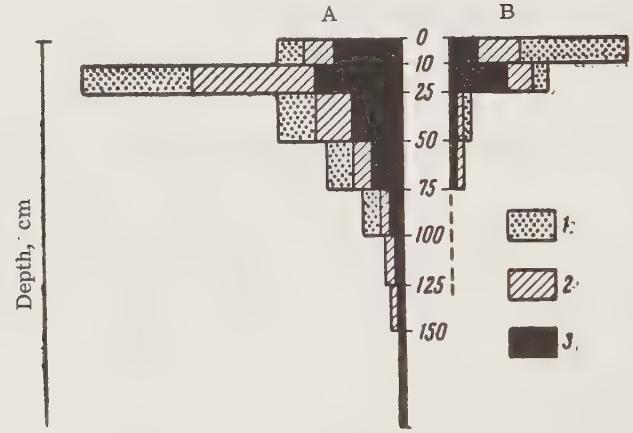

Fig. 3. - Filling of flood-plain forest soils with roots of 18-year-old white acacia with relation to soil salinity.

A - weakly saline soil; B - medium saline soil; 1 - roots with a 3 mm diameter; 2 - roots with a diameter of 1-3 mm; 3 - roots with a diameter of <1 mm.

consumption during the vegetation period (Fig. 4).[1]

Field observations determined that when saline horizons are encountered within the second and third meter of the soil layer, three to fivefold annual irrigation will successfully increase the growth of persimmon, pine, honey locust, pomegranate, and white acacia when the very lowest layers have a salinity of 0.7%-0.8% (Fig. 4).

Conclusions

1. The salinity of a one-meter-thick layer of flood-plain forest and sierozem soils, showing solid residue in excess of 0.4%-0.6%, reduces the growth and survival of a majority of trees under irrigated conditions by 1 1/2 to 2

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[1] Water consumption is the quantity of water used by a year-old oak during a given time interval of vegetation.

Table 6

Comparison of growth and development of year-old oaks with relation to difference in texture and salinity of sierozem soils (pot experiments conducted in 1953-1954)

Indexes	Sandy soil (control)		Typical sandy loam sierozem		Typical clay loam sierozem		Typical clay sierozem	
	Soil salinity based on solid residue, %							
	0.158	0.404	0.062	0.386	0.126	0.362	0.098	0.392
Average height, cm	14.2	11.0	27.9	15.7	21.3	12.4	12.6	9.3
Average diameter, cm	2.8	2.1	3.6	2.9	3.0	2.5	2.5	2.0
Weight of the above-ground portion of the oak, air-dry, g	15.62	12.47	21.47	18.64	19.59	15.71	12.34	10.51
Average number of leaves per tree (each)	9	6	12	7	8	5	7	5
Total leaf surface area of one oak, cm^2	84.69	38.24	158.52	67.69	91.60	41.50	50.68	27.50
Total weight of the roots of one oak, g	7.90	5.16	13.57	8.77	10.72	6.89	5.84	3.92
Included therein, roots having a diameter <1 mm, %	66.1	68.8	63.4	55.6	45.6	43.5	28.3	23.1

Note: Soil moisture throughout the vegetative period was maintained in the range from 85%-90% of field moisture capacity. Quantity of water added daily was taken into account.

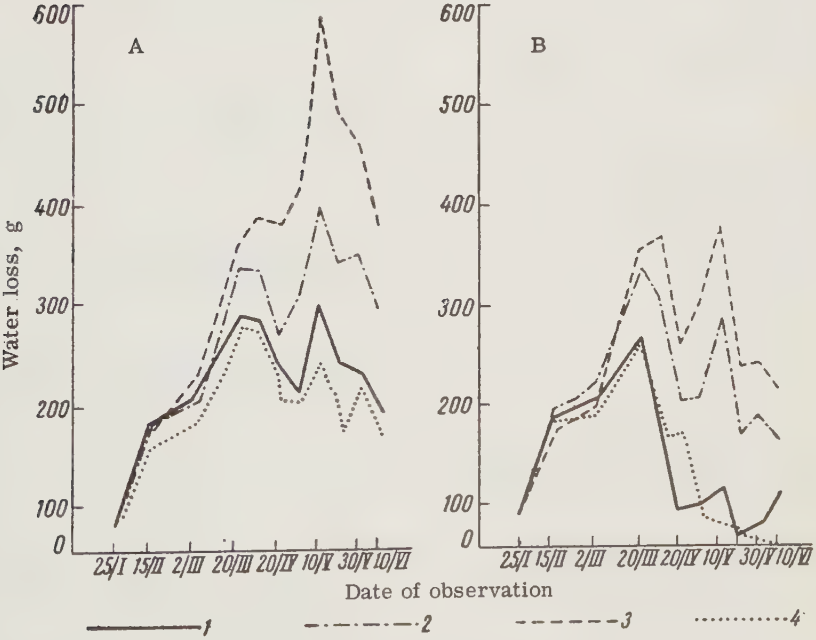

Fig. 4. - Comparison of water requirement of one-year-old oaks with relation to texture and degree of salinity of typical sierozems (based on pot experiments in 1953-1954).

A - non-saline soils (solid residue 0.062-0.158%); B - saline soils (solid residue 0.362-0.404%): 1 - sand (control); 2 - clay-loam sierozem; 3 - sandy loam sierozem; 4 - clay sierozem.

times or more. Such soil salinity affects particularly the accumulation of dry matter, the development of leaf surfaces, and the morphological and anatomical structure of root systems. The roots, upon reaching saline horizons, stop their growth, die, and are decomposed. An insignificant quantity of healthy roots, upon reaching saline soil horizons, are deflected to one or another side and continue their growth horizontally, developing in layers in which soil salinity, as a result of care and irrigation, is considerably reduced.

2. The weak tree growth in saline soils is explained by the relatively high concentration of chlorine ions, which retards the water consumption of the plants and exposes them to water and salt starvation. In that connection, saline soils should be used in forestation only after they have been leached, and protective plantings must take into account the individual salt tolerance of trees and shrubs; a minimum of four to five vegetative irrigations must be carried out.

3. Trees in the irrigated zone of Azerbaydzhan, in terms of their ability to withstand soil salinity, may be classified as follows:

a. In saline soils showing0.6%-1.5% of solid residue in a one-meter layer, Tamarisk and narrow-leaf wild olive will grow successfully;

b. With soil salinity at 0.2%-0.6%, pine, elm, American plane tree, mulberry, white acacia, honey locust, sophora, melia, osage orange, pomegranate and amorpha will grow satisfactorily;

c. In saline soils of 0.15%-0.20% salinity the following will grow well: poplar (Canadian, white-leaf, and pyramidal), green ash, western catalpa, oak (long-stalk and chestnut, walnut, persimmon, willow, and other species.

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DYNAMICS OF NUTRIENT SUBSTANCES IN SOIL AND THEIR UPTAKE BY CORN DURING THE VEGETATIVE PERIOD[1]

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To provide for timely supply of water and nutrients for plants, one must consider factors affecting plant growth and nutrient uptake by the plants during various development phases.

The presence of nutrient substances in the soil manifests itself during the vegetative period. The extent of nutrient uptake by plants during the different development phases can be determined by the amounts of the elements in question contained in the top portion of the plants.

The dynamics of nutrient substances in various soils has been adequately covered in the literature. Nutrients in soils of Voronezh region are discussed in the works of Aderikhin (1, 2, 3, 4), Lazarev (7) Ponedel'nikov (9), Tikhova (10, 12), Tikhova and Trashchaya (13), and others. Nutrient uptake from the soil has not been investigated in sufficient detail with respect to many crops and soils; uptake by corn was studied by Gorbacheva and Rubinova (5), Gorb and Klitsenko (6), Medvedeva (8), and Fotchenko (14).

In view of the importance of corn for forage and food and the need to increase its yield, we conducted experiments[2] in 1955 and 1956 on the dynamics of nutrient substances in the soil and their uptake by corn during the vegetative period; soils tested were leached chernozems in the botanical garden of Voronezh State University and in "Razdol'e" sovkhoz of Semiluksk region, Voronezh district. The humus content in the first case was 6.6%, and in the second case (in "Razdol'e" sovkhoz) — 6.9%. Texture of the soil was fine clay loam.

Meteorological conditions during a two-year period were varied. In 1955 the vegetative period was normal for the given region. In 1956, it was varied: spring was late and precipitation was below normal during June; a heavy rain started early in July and continued almost without interruption until the end of the vegetative period. As a result, soil moisture in the experimental plots was not uniform over the two-year period, and a difference in the dynamics of nutrient substances of the soil was noted (Table 1). In 1955, soil moisture remained at a low level between spring and summer and, later, remained low throughout the fall; in 1956, it was somewhat low from May to June, increased gradually, and remained at a high level through the end of September.

Differences in soil moisture resulting from various methods of soil cultivation were not great. A comparison of the dynamics of nutrient substances, by years, produces the following information. The dynamics of nitrates was not uniform (Table 2).

A maximum nitrate content in the plowland horizon in 1955 was observed during the month of August, while in 1956 the maximum was reached in June, when soil moisture was at a low level. Both years showed minimum amounts of nitrate during September.

The dynamics of nitrates is influenced to some extent by different cultivation methods. Nitrates in larger quantities were found during all periods in the plots; to a lesser extent they were determined in plots plowed with a plow without a moldboard; and to a still lesser extent, in a plot plowed with a moldboard plow.

The ammonium content in soil under corn is not great (as can be seen from Table 3). Its content in the soil remains low from June to September. Different soil cultivation methods did not appear to affect ammonium content substantially.

The amount of hydrolyzed nitrogen in soil under corn changes with time; amounts of

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[1] Presented at the First Delegates' Session of Soil Scientists. May, 1958.

[2] Participants in this project were: Yu. G. Churilina, M. N. Kudryavtseva, and M. T. Kopayeva.

Table 1

Percentage of soil moisture Botanical Garden of Voronezhs State University, 1955

Treat-ment	Depth, cm	April 27	May 13	May 31	June 28	July 21	Aug. 1	Aug. 16	Sept. 20
Control	0—20	21,1	28,2	29,3	24,6	17,8	18,8	22,3	16,4
	20—40	25,7	25,8	29,6	24,5	18,5	17,9	18,1	16,3
	40—60	23,5	23,3	26,0	22,1	22,1	20,0	—	—

"Razdol'e" sovkhoz, 1956

Experimental Scheme	Depth, cm	May 12	May 24	June 6	July 20	Aug. 20	Sept. 26
Plowing without moldboard	0—10	27,96	26,23	18,97	29,67	30,88	28,9
	25—35	30,09	25,35	19,33	28,20	29,50	25,4
	50—60	—	—	17,79	25,54	26,20	23,1
Plowing with moldboard	0—10	27,13	24,22	19,26	28,44	30,63	29,2
	25—35	29,09	24,98	20,53	26,29	28,61	27,6
	50—60	—	—	21,00	25,21	26,94	25,36
Triple disking	0—10	26,96	—	18,38	27,42	31,81	28,6
	25—35	27,15	—	18,85	27,82	27,81	26,23
	50—60	—	—	18,48	22,73	25,54	24,15

Note: Comma represents decimal point.

nitrate and ammonium also vary with time, but to a lesser extent (Table 3).

Different soil cultivation methods do not appear to have an effect on hydrolyzed nitrogen any greater than on nitrates.

Results of an investigation of the dynamics of phosphates appear in Table 4.

In 1955 the soil contained relatively little phosphate, soluble in 0.5N acetic acid; in 1956 the amount of phosphate was almost double that in 1955; in September, 1955, it was at a low level; in September, 1956, it was much higher. It would appear that phosphate content increases with an increase in soil moisture. Changes in the dynamics of phosphates as a result of variations in soil cultivation methods are not extensive.

Available potassium in the soil is characterized by relatively high numerical indexes (see Table 4). It reaches a maximum in June, and is at a minimum in September. Various methods of soil cultivation showed a negligible influence on the content of available potassium in the soil in 1956.

Thus, the dynamics of nutrient substances in soil under corn depends on meteorological conditions of the vegetative period and, to some extent, on soil cultivation methods.

To determine the individual nutrient element uptake from the soil by corn, samples of the plants were analyzed at different development phases. The following were determined: nitrogen, total ash, phosphorus, potassium, and calcium. Let us first examine data on nitrogen content in corn (Table 5).

Nitrogen is contained in corn in maximum quantities during the period of young growth and during the two or three-leaf stage. In subsequent phases, nitrogen content in corn continuously decreases; this points to a decrease in the energy of nitrogen uptake from the soil.

The percentage content of total ash elements in corn is characterized by a curve similar to that for nitrogen, with salt content in straw and grain in 1956 being noticeably greater than in 1955 (Table 6).

Maximum ash content in corn is observed during the two or three-leaf stage, after which their quantity decreases somewhat slowly until the period of bloom is reached; then it decreases sharply until the plant reaches the

Table 2

Nitrates in mg per 100 g of absolutely dry soil. Botanical Garden of Voronezh State University, 1955

Treatment	Depth, cm	April 27	May 13	May 31	June 28	July 21	Aug. 1	Aug. 16	Sept. 20
Control	0—20	2,19	3,18	1,98	2,10	2,51	5,05	1,55	0,98
	20—40	1,59	1,88	2,26	2,39	2,05	1,03	0,53	0,89
	40—60	—	—	0,85	1,89	0,50	1,06	—	—

"Razdol'e" sovkhoz, 1956

Experimental scheme	Depth, cm	May 12	May 24	June 10	July 20	Aug. 22	Sept. 26
Plowing without moldboard	0—10	7,77	9,54	10,34	3,19	2,49	0,484
	25—35	2,09	4,53	3,69	6,68	1,97	Traces
	50—60	—	—	1,15	1,22	1,62	„
Plowing with moldboard	0—10	6,01	7,24	7,23	1,66	2,36	0,495
	25—35	2,34	4,14	4,64	2,92	1,13	Traces
	50—60	—	—	1,25	0,52	0,89	„
Triple disking	0—10	6,73	10,67	12,74	4,06	2,32	0,646
	25—35	4,08	2,86	5,06	6,22	3,02	Traces
	50—60	—	—	0,88	1,43	1,00	„

Note: Comma represents decimal point.

Table 3

Water-soluble ammonia and hydrolyzed nitrogen in mg per 100 g of dry soil. "Razdol'e" sovkhoz, 1956

Treatment	Depth, cm	May 12	May 24	June 6	July 20	Aug. 22	Sept. 26
			Water-soluble ammonia				
Plowing without moldboard	0—10	—	0,44	0,45	0,18	0,29	0,18
	25—35	—	0,40	0,34	0,23	0,21	0,01
	50—60	—	—	0,32	0,16	0,15	0,01
Triple disking	0—10	—	0,45	0,39	0,22	0,29	0,103
	25—35	—	0,59	0,39	0,17	0,23	0,051
	50—60	—	—	0,43	0,15	0,19	0,051
Plowing with moldboard	0—10	—	0,35	0,38	0,19	0,17	0,024
	25—35	—	0,34	0,38	0,18	0,17	0,023
	50—60	--	—	0,33	0,16	0,17	Traces
			Hydrolyzed nitrogen				
Plowing without moldboard	0—10	9,97	11,50	12,49	6,09	4,0	4,19
	25—35	0,21	—	5,14	7,21	3,97	3,68
	50—60	—	—	4,93	6,58	4,01	3,34
Triple disking	0—10	7,89	11,96	15,88	7,48	5,33	4,32
	25—35	4,67	4,96	6,20	7,50	4,12	2,64
	50—60	—	—	4,30	7,62	4,76	2,78
Plowing with moldboard	0—10	8,03	9,54	9,69	6,71	3,38	3,60
	25—35	7,19	5,85	6,64	9,75	3,11	2,95
	50—60	—	—	4,06	7,53	3,51	2,25

Table 4

Available phosphates and potassium (P_2O_5 and K_2O) in mq per 100 g of dry soil phosphates. Botanical Garden of Voronezh State University, 1955

Treatment	Depth, cm	April 27	May 13	May 31	June 28	July 22	Aug. 1	Aug. 16	Sept. 20
Control	0—20	4,53	4,97	5,85	4,84	5,29	5,20	5,49	2,82
	20—40	4,19	4,72	2,59	4,63	2,81	6,03	4,37	4,46
	40—60	—	—	2,74	—	—	—	—	—

Phosphates. "Razdol'e" sovkhoz, 1956

Experimental Scheme	Depth, cm	May 12	May 24	June 6	July 20	Aug. 22	Sept. 26
Plowing without moldboard	0—10	7,74	—	11,14	10,0	13,13	13,78
	25—35	7,32	—	9,14	9,45	14,02	9,83
	50—60	—	—	6,36	5,54	9,88	13,38
Plowing with moldboard	0—10	7,69	—	13,65	12,09	12,02	19,80
	25—35	7,45	—	43,45	9,46	7,28	20,82
	50—60	—	—	10,97	4,66	5,60	13,58
Triple disking	0—10	7,53	—	13,96	12,11	12,18	16,03
	25—35	7,71	—	9,63	5,57	6,65	10,27
	50—60	—	—	6,87	6,12	5,89	15,43
Available potassium. "Razdol'e" sovkhoz, 1956							
Plowing without moldboard	0—10	11,68	15,02	24,06	11,93	23,97	9,05
	25—35	10,28	7,40	13,36	8,84	11,91	not det.
	50—60	—	—	13,19	6,91	11,61	»
Plowing with moldboard	0—10	12,08	11,80	22,43	19,65	19,98	6,81
	25—35	10,20	9,87	13,50	11,65	11,83	not det.
	50—60	-	—	16,34	13,77	11,57	»
Triple disking	0—10	12,06	13,07	20,13	14,02	18,06	10,00
	25—35	10,04	10,80	16,04	11,76	11,76	not det.
	50—60	—	—	11,84	11,52	11,55	»

Note: Comma represents decimal point.

nilk stage. Different methods of soil cultivaion, tested with respect to the corn planted in .956, did not seem to affect its nitrogen and ash ontent.

Certain peculiarities in the assimilation of sh elements into corn were noted during the egetative period (Table 6). Based on 1955 lata, corn absorbed phosphorus primarily duing the period of young growth. In the subseuent stages the phosphorus content in corn ecreased quite sharply. In 1956, changes in he phosphorus content in corn, over the ifferent development stages, were relatively nsignificant; during the harvest, phosphorus ontent in straw and grain was approximately double that in 1955; this is attributed to meteorological conditions during the vegetative period.

Data on the potassium content in corn are given in Table 6. In 1955, it was at its maximum during the three-leaf stage, while in 1956 it was high during the blooming stage. Toward the end of the vegetative period, potassium content in corn decreased. The quantity of potassium in the plant was higher in 1956 when more available potassium was contained in the soil. Methods of soil cultivation appeared to have no influence on the potassium uptake by corn.

Of some interest are data on calcium in

Table 5

Nitrogen content in corn, % of absolutely dry substance.
Botanical Garden of Voronezh State University, 1955

Treatment	May 31	June 29	Aug. 1	Aug. 16	Sept. 20	
	Sprout stage	3-leaf stage	Bloom stage	Milk stage	Harvest	
					Straw	Grain
Control	4.64	4.06	1.67	1.49	0.38	1.78
"Razdol'e" sovkhoz, 1956						
Experimental scheme	June 6	July 10	July 20	Aug. 22	Sept. 26	
	2-3 leaf stage	Tassel	Bloom stage	Milk stage	Full maturity	
					Straw	Grain
Plowing without moldboard	5.60	3.54	2.84	1.55	1.03	2.02
Disking	5.69	3.36	3.18	1.69	0.98	1.59
Plowing with moldboard	5.54	3.37	2.84	1.73	0.99	2.02

corn (Table 6). Compared to other elements, calcium is taken up by corn in small quantities. Its content in plants is at its maximum during the two- or three-leaf and tassel stage; during the last stages it gradually decreases. There is very little calcium in the corn grain, the amount is approximately 1/8-1/12 that of straw.

The accumulation of dry substances in corn during the vegetative period follows a rising curve and is affected by changes in soil cultivation methods (Table 7).

Under conditions prevailing in 1956, accumulation of the dry substance was particularly substantial as a result of plowing with a moldboard plow; disking proved least effective. The nutrient uptake, by corn, from the soil (calculated on a per-hectare basis) takes place not uniformly, but also follows a curve. Let us examine it with respect to a plot plowed with a moldboard plow (Table 8).

The nitrogen uptake during the first (three-leaf) stage is insignificant; with the increase in vegetation mass it sharply increases; after blooming, it slows down to some extent. Thus, during tassel and bloom stages corn requires nitrogen in large quantities; nitrogen, in available form, must be present in the soil during that period. The grain contains more nitrogen than the straw. Of the ash elements, corn takes up potassium in largest quantities. Particularly great is its need of this element during the stage of tasseling and blooming. Potassium, contrary to nitrogen, is taken up in large quantities by the straw rather than the grain. After blooming, uptake of phosphorus from the soil by corn does not slow down, as in the case of nitrogen and potassium, but, on the contrary, rises sharply. Corn's need of phosphorus does not abate until the end of the vegetation period. Like nitrogen, it is taken up in larger quantities by the grain rather than by the straw. Corn extracts very little calcium from the soil, and calcium uptake follows the same curve as that for phosphorus. The grain extracts up to 2 kg of calcium per hectare.

Data obtained by us show that corn's need of the various nutrients is not uniform during all stages of its development. It extracts mostly potassium and nitrogen, somewhat smaller amounts of phosphorus, and minor quantities of calcium. When cattle are fed ensilage corn and grain, the fact that corn contains little calcium must be taken into account. Therefore, calcium must be added to the forage. Grain is a valuable feed because of its high nitrogen and phosphorus content.

Conclusions

1. Content and character of the dynamics of nutrients such as nitrogen, phosphorus, and potassium in the soil was not uniform in 1955 and 1956, because of the difference in meteor-

Table 6

Ash elements in corn as % of dry substance. Botanical Garden of Voronezh State University, 1955

Treatment	Elements determined	May 31	June 29	Aug. 1	Aug. 16	Sept. 20	
		Sprout	3-leaf stage	Bloom stage	Milk stage	Harvest	
						Straw	Grain
Control	Ash	14,23	10,89	5,71	4,18	4,41	1,56
	P_2O_5	1,44	0,74	0,42	0,39	0,07	0,45
	K_2O	0,99	2,45	1,09	0,96	1,01	0,45

"Razdol'e" sovkhoz, 1956

Experimental scheme	Elements determined	June 6	July 10	July 20	August 22	Sept. 26	
		2-3 leaf stage	Tassel stage	Bloom stage	Milk stage	Harvest	
						Straw	Grain
Plowing without moldboard	Ash	11,77	11,14	10,07	5,65	7,28	2,10
Plowing with moldboard	»	10,23	9,15	10,10	6,22	7,15	2,17
Triple disking	»	12,67	11,05	4,61	5,85	7,25	2,04
Plowing without moldboard	P_2O_5	0,81	0,90	0,73	0,77	0,38	1,08
Plowing with moldboard	»	0,77	0,82	0,86	0,77	0,36	1,02
Triple disking	»	0,84	0,86	0,84	0,74	0,30	1,00
Plowing without moldboard	K_2O	2,26	3,85	3,23	1,80	1,69	0,68
Plowing with moldboard	»	2,34	3,93	3,24	1,86	1,64	0,68
Triple disking	»	2,63	3,81	3,22	1,83	1,62	0,58
Plowing without moldboard	CaO	0,544	0,572	0,432	0,305	0,379	0,028
Plowing with moldboard	»	0,621	0,572	0,389	0,282	0,321	0,030
Triple disking	»	0,676	0,765	0,416	0,284	0,251	0,036

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ote: Comma represents decimal point.

Table 7

Accumulation of dry substance in corn (weight of air-dried mass in kg/ha). "Razdol'e" sovkhoz, 1956

Treatment	Development stages and dates						
	June 6	July 10	July 20	August 22	September 26		
					Full Maturity		
	2-3 leaves	Tassel	Bloom	Milk stage	Total	Straw	Grain
Plowing without moldboard	1,629	1567,0	5286,0	11347,0	13204,0	7265,0	5929,0
Plowing with moldboard	1,808	2290,0	5571,0	11837,0	13367,0	7892,0	6775,0
Disking	1,608	1233,0	4084,0	7408,0	8469,0	4537,0	3932,0

Note: Comma represents decimal point.

Table 8

Nutrient uptake by corn in kg per ha and their extraction by harvest. "Razdol'e" sovkhoz, 1956

Nutrient substance	Development stage and dates					
	June 6	July 10	July 30	Aug. 22	Sept. 26	
	2-3 leaf	Tassel	Bloom	Milk	Full ripeness	
					Straw	Grain
Nitrogen	0.103	76.94	177.16	181.05	69.09	116.53
Total ash	0.229	253.05	562.67	643.40	542.83	138.01
Phosphorus	0.015	16.69	46.80	91.14	27.33	69.00
Potassium	0.048	87.25	180.50	190.58	148.95	46.07
Calcium	0.012	13.23	21.67	31.01	25.33	2.03

ological conditions during the vegetative period. The year 1956 was more favorable for the mobilization of nutrients in the soil because the soil in that year contained more available nitrogen, phosphorus, and potassium, than in 1955.

2. Plowing without moldboard under conditions prevailing in 1956 did not appear to have any advantage over plowing with moldboard, both in terms of availability of nutrients and in terms of corn yield. However, either method of plowing was more effective than disking. Development of corn on the disked plot lagged behind that on the plots plowed either with or without moldboard.

3. During the early development stages, corn absorbs maximum quantities of nitrogen, phosphorus, and potassium from the soil; the energy of uptake increases gradually up to the period of full maturity.

4. Amounts of nutrients contained in corn during full maturity are, in descending order: in straw — potassium, nitrogen, phosphorus, calcium; in grain — nitrogen, phosphorus, potassium, and calcium.

5. Corn extracts from the soil potassium in largest quantities, nitrogen in somewhat smaller quantities, phosphorus in noticeably smaller amounts, and calcium in negligible amounts.

6. In view of the fact that corn straw contains very little calcium, calcium additive must be provided when ensilaged corn is used as cattle feed.

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DETERMINATION OF WATER-SOLUBLE GYPSUM IN SALINE SOILS

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The study of saline soils usually requires a knowledge of their gypsum content. This is particularly important in the study of solonetz and solonetz-like soils and in the investigation of the influence of irrigation on saline soils. Gypsum content in the soil is considered by many researchers to be based on the quantity of $SO_4^=$ in hydrochloric extraction, without taking into account the quantities of $SO_4^=$ in water-soluble gypsum. To determine the latter, additional calculations are usually carried out after all analytical data have previously been put in equivalent form. Water-soluble gypsum content can sometimes be considerable, of the order of 0.5%-0.7% $SO_4^=$ (of weight of the soil); such a quantity of gypsum obviously cannot be taken into account, particularly in cases where the total gypsum content is not in excess of 1%, 2% or 3%$SO_4^=$.

Data on gypsum content in soils of the Mel'sk plain indicate that, to determine quantities of $SO_4^=$ of water-soluble gypsum, it is not necessary to perform lengthy calculations with subsequent reduction of results of the analysis to equivalent forms. It is sufficient to use only the magnitude of the percentage content of the Ca^{++} in water extract. The relationship between the $SO_4^=$ content of water-soluble gypsum and Ca^{++} in water extract can be expressed by a linear equation, shown in Figure 1. The $SO_4^=$ content of water-soluble gypsum $y = 2.4\ (x-0.01)$ percent of soil weight; x is the content of the Ca^{++} in water extract; the value 0.01% represents the quantity of Ca^{++} fixed in the form of bicarbonate; analysis shows that this magnitude changes little during the change in the saline composition of water extracts (from 0.008%-0.014%). This method for the determination of $SO_4^=$ content in water-soluble gypsum is obviously much more rapid than lengthy computations, the more so since in this determination the graph shown in Figure 1[1] may be used.

The quantity of water-soluble gypsum may serve as a certain guide to the determination of total gypsum content in soils (see Fig. 2). It is not possible to obtain accurate data on the total gypsum content in soils based on the quantity of water-soluble gypsum, since there is no direct relationship in the solubility of gypsum in water. Solubility of gypsum in water is associated with the total composition of the salts present in soils and it varies from 2%-70%. Data on gypsum content in the soils of the Mil'sk plain indicate that in the case of sulfate-chloride salinity of soils the solubility of gypsum in water constitutes an average of 20%-30%, sometimes rising to 40%-60% and even higher; the more gypsum contained in the soil, the lower its solubility. In the case of chloride-sulfate salinity of soils, solubility of gypsum is considerably lower and constitutes only 10%-15% of total gypsum content. In sulfate salinity of soils the solubility of gypsum is reduced to 3%-6%.

The interrelationships between total gypsum content in the soil, its solubility in water, and the quantity of water-soluble gypsum in soils of the Mil'sk plain, under various types of soil salinity conditions, are shown in Table 1. Compilation of this table is based on a total of 176 determinations.

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[1] It should be noted that the presence of $CaCl_2$ in soil invalidates this method.

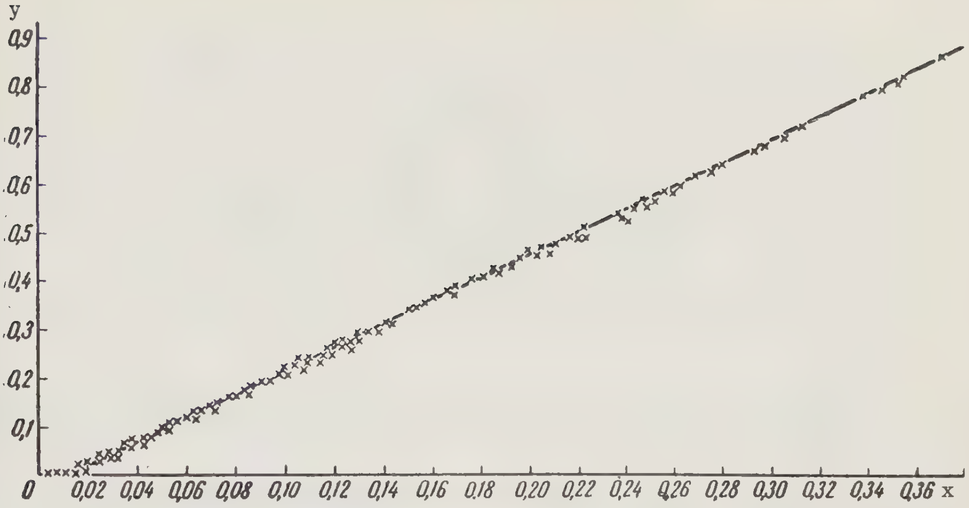

Fig. 1. - Determination of $SO_4^=$ content of water-soluble gypsum based on Ca^{++} content in water extractions $y = 2.4(x - 0.01)$

y - $SO_4^=$ content of water-soluble gypsum, % of soil weight

x - Ca^{++} content in water extract, % of soil weight.

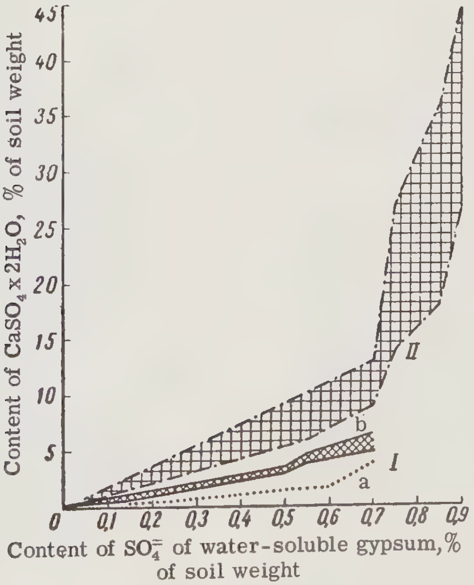

Fig. 2. - Relationship between quantity of $SO_4^=$ of water-soluble gypsum and total content of $CaSO_4 \times 2H_2O$ in soils of the Mil'sk plain.

I - (sulfate)-chloride salinity: a - individual cases; b - average data; II - (chloride)-sulfate salinity.

Table 1

Gypsum content in soils and its solubility in water under various soil salinity conditions
(analysis by V. S. Muratova and Z. S. Vlatova)

Type of salinity	$SO_4^=$ of water-soluble gypsum, % of soil weight	Solubility of gypsum, % of its over-all content in the soil (from averaged data)	Gypsum content, % of soil weight	
			$SO_4^=$	$CaSO_4 \times 2H_2O$
Mixed	0—0,05	>25	$<0,2$	$<0,4$
Primarily chloride	0,05—0,50	30—25	0,2—2,0	0,4—3,6
Primarily sulfate	" "			
Sulfate-chlor.		15—10	0,3—5,0	0,5—9,0
Chloride-sulfate	0,50 - 0,70	25—20	2,0—3,5	3,6—6,3
	" "	15—10	3,5—7,0	6,3—13
Sulfate	0,70—0,90	10—6—3	7—15—25	13—45

Note: Comma represents decimal point.

REVIEWS

PRINCIPLES OF AGRONOMY, VOLUME II. GROWTH AND DEVELOPMENT OF CULTURAL CROPS, A. Demolon. Paris, 1956.

A fifth edition of A. Demolon's book was published in Paris; while it was prepared for publication by the author, it was published by P. Boischot, his student, after the death of the author in October, 1954.

The book is a substantial one and represents a definitive treatment of questions of plant growth. If one is to take into account that in Volume I of Principles of Agronomy, the author thoroughly and fully covered questions of soil science, one concludes that Demolon (one of France's most outstanding scientists) has covered in great detail the most important theoretical topics in agronomy.

Demolon's presentation is original and shows a deep insight and objective approach to the question, based on available literature and materials prepared by the author. The book is of considerable interest to our readers since it touches upon certain questions that have been little covered in the agricultural literature, while well-known questions are frequently given a new and original light, and new factual data are presented. In his foreword to the first edition of the book, Demolon wrote: "Instead of collecting a large number of facts which are frequently not related and may even be in contradiction, we have grouped together into one whole the newest and most accurate observations and investigations with respect to certain basic ideas. It is not enough to determine the complexity of a problem; to the extent that phenomena can be described in terms of laws of behavior and experiments, agronomy will become a strict scientific discipline."

In the foreword to the last edition, Demolon again returns to this question and cautions that inability to foresee the results of one or another process under conditions of present knowledge should not make us deny their existence.

All phenomena in agronomy follow the laws of physics, chemistry, and biology, and it is the task of science to substitute the existing empirism of scientifically governed relationships that explain the interrelationships between cultural crops, soil, and climate. To understand, stated Demolon, is to progress, and the opportunities for progress are limitless.

To enable the reader to obtain a general impression of the book, within the framework of the review, we must discuss its subdivisions. The book consists of an introduction and four major parts: 1) physical factors in plant growth, 2) chemical factors in plant growth, 3) biological factors and plant growth, 4) growth and yield.

The word growth (croissance) is used by Demolon in its broadest sense; thus, in all parts of the book, growth and plant development are examined interchangeably.

The author attaches considerable importance to the study of the influence of external conditions on growth; this knowledge, in his opinion, is absolutely mandatory for the agronomist; without this knowledge no correct solution of agricultural measures is possible. He examines in detail the influence of light on the growth, respiration, transpiration, and photosynthesis of plants. Data given on the change of light intensity, with change in geographical latitude, and on the influence of light intensity on assimilation, depending on the concentration of carbon dioxide, give a clear picture of the possible intensity of assimilation under natural conditions.

Presented are the principles of photoperiodism, the significance of light intensity, and possibilities for the utilization of artificial light. Also shown is the linear relationship between the logarithm of light intensity and assimilation, and also the growth of the leaf surface; for the first quantity this relationship is linear, while for the latter it is inverse, which governs the growth of plants in accordance with a parabolic equation with a maximum during the determination of light intensity.

Treated in similar detail is the influence of temperature on the physiological processes in plants. Shown is the significance of the change between day and night temperatures. Given a constant temperature of 25°C the daily growth of tomatoes was approximately 21 mm; however, if the temperature dropped to 18°C at night, the increase in the growth of tomatoes was 27 mm. Shown also were the interaction between light and temperature on the growth of plants and the variation of these two indicators in the course of a year, in moderately tropical latitudes.

With respect to mineral nutrition, Demolon states and solves two problems: 1) the determination of plant requirements of various nutrients, and 2) the methods that would assure the entry of these nutrients under conditions most favorable for the full development of the plants.

Demolon attaches great significance to the ability of plants to take up nutrients actively and selectively and considers such processes as transpiration and diffusion as playing a subordinate role. As proof he presents, along with other data, results of an experiment conducted by D. M. Prianishnikov with sugar beets; given identical intensity of transpiration, varying quantities of KCl are taken up, with the interrelationship between the K^+ and Cl^- varying strongly with relation to the plant's requirements.

During the nutrient uptake by plants, direct significance is attached to soil and plant colloids. It has been shown that in the presence of kaolinite in the soil, plants take up more calcium; in the presence of bentonite, they take up more potassium. In addition, the exchange capacity of root systems also varies. With respect to monocotyledonous plants, it does not exceed 25 meq/100 g of dry substance, while, with respect to dicotyledonous plants, it is double that. Colloids with increased exchange capacity primarily absorb divalent cations, while those having a lower exchange capacity absorb univalent cations. This explains to a considerable degree the difference in structure between mono- and dictyledonous plants. An important role is ascribed to phenomena of ionic antagonism. Ion absorption is regulated by their utilization on the part of plants during the metabolism process.

Stressing the selective absorption of ions by plants, Demolon again cites Prianishnikov's data which show that, from identical solutions, grain-crops required up to 85% meq of Cl^- compared with K^+, taken as 100%, while peas required only 11%, and beets only 14%. Plants react more quickly to nutrients through the leaves than by way of their roots: Demolon recommends that this method be used to determine reasons for the external signs of nutritional deficiencies and to give plants microelements.

Considering that full development of plants can be achieved in a sterile mineral environment, Demolon writes that bacterial activity in the soil is of considerable interest in the study of the influence of such activity on growth.

The book treats questions of mineral nutrition broadly, but a brief review does not afford the opportunity to review all of these in detail. We shall note only certain premises that illustrate the author's views.

Taking into consideration the existence of an isotope exchange between plants and the soil, Demolon considers the isotope method as inapplicable for the determination of the utilization coefficient of fertilizers. Demolon considers leaf diagnosis as suitable for evaluation of the correctness of plant nutrition. He defines nutritional intensity as the sum of percentages of N, P, and K in the leaf, while nutritional quality is expressed as the interrelationship of these elements.

Utilization of nutrients depends to a great extent on the nature of the plant. Even the same plant varieties may differ to a considerable extent in terms of their utilization of nutrients. Thus, to form 100 g of sugar, red beets require 5. 5 of K_2O, while sugar beets, containing twice the quantity of sugar, require only 2. 3 g. Total content of minerals in red beets reaches 12% of the dry substance, with sugar beets accounting for only 3%. Climatic conditions also affect the composition of plants. In experiments with oats, increased soil moisture increased considerably the content of all plant nutrients.

Demolon considers that the interrelationship among the elements reflects the character of plant nutrition at each stage of development in a given environment. Within certain ranges, plants are capable of assuring uniformity of these interrelationships. Disruption of the nutritional process is the result of a disturbance of these interrelationships.

Plant nutrition by the principal elements is looked upon in various ways. For example, with respect to nitrogen nutrition, there are presented: ways of synthesis of albuminous substances in plants and the change in their composition and quantities in various plants during growth; the percentage content of nitrogen in plant organs; nitrogen requirements of yield; sources of nitrogen nutrition; extent of nitrification in various soils; nutrition through ammonia and nitrate nitrogen; fixation

of nitrogen by the leguminous plants and the
significance of biological nitrogen in agricul-
ure; and cultivation of legume — grass mix-
ures. Considering the planting of grasses as
an important means to increase soil productiv-
ty, Demolon notes the fallacy of the view that
use of grass mixtures is always better than the
planting of pure legume crops.

The book contains data on the efficiency of
various forms of fertilizer for various crops
n France and examines the conditions that
determine the efficient amounts of fertilizers,
as well as methods and time of their applica-
ion.

Somewhat unexpected appears to be Demolon's
conclusion that the efficiency of nitrogen fertil-
zers is great when grain crops have a smaller
plant rate. Data presented show that, when
densely planted, spring barley plants have
ess stalks; however, this appears to be so
whether or not nitrogen is introduced. As for
ncreased stalks resulting from increased use
of nitrogen fertilizers, the introduction of
nitrogen (24 kg/ha) with normal rate of plant-
ng seed at 70 kg/ha, increased the stalks by
19% while, when 135 kg of seed were planted
per hectare, the increase was 18%; thus, the
ncrease was identical, regardless of sowing
rate. Unfortunately, no data were presented
with respect to the yield and this makes it
mpossible to judge the efficiency of nitrogen
with respect to seed planted at various rates.

The application of manure alone results in
waste; it is frequently sufficient to introduce
only 1/4 of the nitrogen contained in manure
n the form of mineral fertilizers, and the
ame effect is obtained. Based on experi-
ments conducted by Gyuyon, Demolon notes
hat, when 15-20 metric tons of manure are
used per hectare of potatoes or rye, an
additional 59 kg/ha of nitrogen in the form
f mineral fertilizer must be introduced.
Thus Demolon corrects the widespread
misconception that manure is primarily a
itrogen fertilizer. References to this are
lso found in our literature.

Regarding nitrogen-fixing bacteria he ex-
presses the opinion that they turned out to be
nefficient in agricultural practice because
itrogen fixation is largely dependent on en-
ironmental conditions, certainly more so
han the introduction of bacteria which are
ormally found in the soil. Summarizing a
arge number of experiments, Demolon deter-
mines the mean efficiency of 1 kg of mineral
itrogen fertilizers: 1 kg of nitrogen yields
n increase of 10-20 kg of grain, 50-90 kg of
ugar beets, 100-200 kg of red beets, 50-100
g of potatoes, and 40-60 kg of hay.

The coefficient of nitrogen utilization, com-
uted on a comparative basis of uptake by plants from fertilized and non-fertilized plots, is considered inaccurate by Demolon since fertilizers were introduced into fertile soils; however, he presents such calculations and assumes that in practice the uptake of nitrogen as mineral fertilizer must be considered satisfactory at 50%. Uptake of nitrogen from manure, over a period of a year, did not exceed 20%-30%.

Questions of plant nutrition by phosphorus and sulphur are also discussed in great detail. The results of initial experiments with radioactive isotopes are presented.

Of interest are the conclusions on the role of phosphorus in agricultural practice during the war years of 1940-1945, when there was a great shortage of phosphorus fertilizers in France. With respect to grain crops, along with reduced yields, a reduction in the resistance to frost and firing was noted; similarly, a reduction in the yield of beets and potatoes to the extent of 50% was observed; for grasses, the composition in mixture changed; grapes ripened late and a reduction in their quality was determined.

Work of our scientisits is referred with respect to a number of questions; on the question of availability to the plants of phosphate fertilizer, an analysis is made of the works of D. N. Pryanishnikov, M. K. Domontovich, S. M. Rozanov, and V. V. Butkevich. Demolon does not think highly of rock phosphate as a fertilizer; this apparently, is due to the properties of North African rock phosphates and the predominance of neutral soils in France.

In the examination of plant nutrition by potassium, considerable attention is devoted to the antagonism of cations and to the effect of external climatic factors on the entry of potassium into the plant; specifically, Demolon's experiments showed that artificial shading of grapes considerably increased potassium content in the leaves.

The discussion of the need for adding phosphate devotes particular attention to soil analysis and, in the determination of the plants' need for potassium, the external appearance of the plant, in addition to soil analysis, is significant.

The potassium requirements of plants varied considerably when computed on the basis of dry mass formed by the growths, productive yield (grain, tubers), or useful end product obtained (sugar, starch). Because of this, Demolon notes that the average potassium content may not be considered the basic content when the plant's actual requirements are established. He also notes that 1 kg of K_2O assures a 5 kg increase in the wheat yield; this increase, for potatoes, is 18, for beans, 4. 5, and for onions, 3 kg, provided fairly large amounts of fertilizer (approximately 100 kg of K_2O/ha) are added.

Large commercial farms in France frequently use up to 1000 kg of potassium fertilizers per hectare. Experiments at the experimental station in Reims, in plots consisting of silty clay loam, showed that potassium has a significant effect if 100 kg of K_2O/ha are applied annually; beet yield increased from 188-445 cntr/ha; clover hay from 502-1740 kg/ha (dry substance); wheat from 12. 9-23. 9 cntr/ha; potatoes from 102-294 cntr/ha. However, with yields at this level, potassium content of soil was seriously depleted; over a period of 10 years the exchangeable potassium content on the control plot decreased from 0. 34-0. 06 meq of K_2O, while on the fertilized plot it decreased to 0. 2 meq K_2O. Most sensitive to potassium deficiency were potatoes and clover, and it becomes practically impossible to grow these on the control plots after 14 years.

The general apprehension with respect to the harmfulness of the chlorine added with the fertilizer is considered exaggerated by Demolon; in his experiments, potatoes withstood amounts to 400 kg of KCl or 100 kg of sylvanite without loss of quality, provided that fertilizers were added one to two months prior to planting.

Considerable attention is devoted to additional nutrients such as Ca, Mg, Si, Fe, as well as to microelements. When more Ca than K is present, the water uptake by plants is slowed down and transpirtation is increased at the same time. When more Mg than Ca is in the soil, this circumstance usually results in a decrease in yield. The relation, in forage crops, between the total of oxides of alkaline earths (CaO + MgO) and phosphoric acid, had considerable influence and great significance on the nutrition of animals, particularly of young stock. Supplementation of magnesium to soil is best accomplished by utilization of calcareous materials that contain magnesium; if magnesium supply is low, plants may be limited in their growth. In neutral clay soils at Versailles, where magnesium content is one-twelfth that of Ca content, plants were adequately supplied with magnesium. Magnesium deficiency is noted in apple orchards of Isle-de-France and Orleans, which was reflected in reduced yields and the appearance of necrosis on the leaves. However, the requirement for Mg fertilizers is most likely an exception rather than the rule and regular applications of magnesium fertilizers at the present time are superfluous.

The significance of silicon for plant growth is explained by Demolon in terms of its action on the availability of phosphorus in the soil and the fact that, as a result of the formation of colloidal compounds between silicon and iron, the iron uptake by the plants is assured even in cases of alkaline reaction of the soil. Silicon content is highest in the straw of grasses — up to 80% of the weight of the ash — but this does not have a positive rigidity effect on the stems.

During chlorosis the iron content in leaves may even increase, but it is in a bound state and the destruction of normal activity of the plant takes place when there is an increased content of soluble forms of nitrogen and potassium and when there is a reduction in the ratio between Ca and K. Chlorosis has an industrial significance with respect to vineyards and fruit trees; in preventing chlorosis good results are obtained by iron salt sprays or the introduction of iron salt directly into the branches or trunks of the trees.

Effectiveness of microelements in the soils of France turned out to be insignificant; this is explained by the author by the low level of soil leaching and the regular application of organic fertilizers that contain microelements. The physiological role of Cu, Zn, Mn, B, Mo, and Co is thoroughly examined and examples of their insufficient supply are given. Reference is made to the difficulty in determining the deficiency of microelements by chemical analysis; a description of external deficiency symptoms of individual microelements is given and it is recommended that a diagnosis be checked by spraying of plants with the required element.

A special chapter is devoted to the toxicity in agriculture resulting from natural causes, such as anaerobic conditions of the soil, or the release, by the roots of one type of plant, of substances that are toxic to other plants; toxicity may also result from adding certain chemical compounds into the soil.

Demolon concludes that damage by chlorine salt is usually exaggerated by researchers. Under conditions that prevail in Holland, where sections of the sea bottom have been utilized, it is possible to raise certain crops even when the NaCl content per liter of soil solution is 5 g. Magnesium chloride is more toxic. Even much more dangerous are compounds of fluorine and boron, chlorates, and thiocyanides.

In earlier years the negative action of cyanamides was frequently observed. At the present time, cyanamides are normally used as herbicides. Dicyanamide, based on available data, is of no benefit to plants, since it is not decomposed by soil microorganisms; it does not normally affect plants by toxic action. A detailed method is presented for the seedling treatment and for the preparation of various herbicides, with due attention to the possible residual effect of these substances on the growth of cultural crops.

In examining the interrelationship between growth and environment, considerable attention is devoted to the role of microorganisms. Demolon stresses that while natural vegetation on earth varies greatly, the population of soil microbes remains qualitatively almost uniform. Microbes multiply with particular intensity in the rizosphere of the roots, thus furthering the development of plants as a result of the mineralization of the organic substance, the increase in liberation of CO_2, and the fixation of the atmosphere's nitrogen. The favorable interaction of plants and microbes results in the fact that in addition to obtaining high yields, the fertility of the soil is increased.

The role of the nodule bacteria is not limited to nitrogen fixation, they exert a favorable influence on the development of plants and the ripening of seed as the result of the formation of auxins in the nodules. Loss of alfalfa is described by Demolon by the appearance in the soil of a bacteriophage that infects the nodule bacteria. As a means of combatting this phenomenon, it is recommended that nodule bacteria species capable of resisting the bacteriophage be employed. At the end of this chapter Demolon examines the interaction between plants and various disease carriers in the soil, the change in plant composition under the influence of pathogenic fungi, and the role of mineral nutrients in preventing plant diseases.

The latter part of his work is devoted to the relationship between growth and productivity of plants; Demolon begins by defining the concepts of growth (la croissance) and development (le dévelopment); he treats the former as the increase in height and weight of a plant, while the latter is defined as a series of stages, depending on ecological conditions, with each stage being affected by its own peculiar properties and external conditions.

Effect on plants is examined on the basis of natural environment conditions: water, light, temperature, CO_2, mineral substances of the soil, and microelements. He considers the reaction between the soil and its structure as proceeding indirectly. A brief examination of the role of stimulators and growth inhibitors is also given.

Intensity of growth during the period of vegetation changes constantly and is presented in the form of a curve with a maximum at its center; however, for short periods of time, growth intensity (r) can be considered constant and can be expressed as

$$r = \frac{P_2 - P_1}{0.5\,(P_1 + P_2)},$$

where P_1 is the weight of the dry mass in the beginning growth, and P_2 at the end of the period under consideration. Growth of intensity depends basically on the intensity of assimilation; it is lower with respect to grasses, somewhat higher with respect to potatoes, and even higher than that with respect to sugar beets.

To indicate the effect of temperature and light on the intensity of additional growths, Demolon reports an interesting experiment with a grapevine that grew on the outside of an unheated greenhouse. One of the branches was inside the greenhouse where the temperature, on the average, was 5°C higher and the amount of light was some 30% less than on the outside. The branch inside the greenhouse grew three times more rapidly than that on the outside.

Evaluation of effects of external factors of plant growth included the examination of the laws of minimum and limiting factors, the optimum concentration of the nutrient solution, and the successively decreasing additions of yield resulting from an increase in the intensity of the same growth factor after Mitscherlich. With regard to Mitscherlich's formula, a number of comments were made; specifically, reference is made to the instability of the coefficients of growth factors "C". The fairly good agreement between experimental data and the theoretical curve is explained by the fact that, even with considerable change of coefficients, calculations result in data that are close for amounts used in actual practice. Maximum yield "A" has only relative significance, since it is examined with respect to only one factor, while all other factors remain constant.

The author continues to examine, on the basis of concrete examples, the antagonism and synergism of various growth factors and the possible maximum of relativity. For France, the sum of precipitation is approximately 600 mm; to the extent that, during formation of 1 kg of dry substance, a total of approximately 600 kg of water is evaporated. Demolon considers, that the maximum possible yield may be up to 10,000 kg. Actually, on the average for a period of 9 years, on deep fertile soils, yield reached 8,318 kg. Under irrigation, such crops as corn, sorghum, and alfalfa may form up to 15,000 kg of dry mass/ha.

In his examination of fertilizer application, Demolon takes into account nutrient loss caused by drainage removed by harvest, the role of soil reserves and fertilizers in the nutrition of crops. He considers that nitrates that are formed in the soil during the growth of the plants, are used almost completely, while total available phosphorus, determined with the aid of citric acid extraction, are utilized to the extent of 5-15%, depending on soil properties and crops under cultivation; total available potassium in the soil is utilized by plants to the extent of 10%-30%.

Effectiveness of fertilizers depends not only on the amount applied, but also on their ratios. During the experiments various ratios were examined, with identical total quantities of nutrients. The optimum ratio for oats was determined as N: P_2O_5 : K_2O = 40:30:30, and, for tomatoes, as 20:50:30. Average ratios of nutrients used in the different regions of France vary greatly: in the north the ratio of N:P_2O_2:K_2O equals 1:1. 1:1.1; in the east it is 1:2. 4:1. 7, while the central Massif has a ratio of 1:4. 5:0. 9. French experimental stations, in determining amounts of fertilizer, rely on the principle that, in the first place, it is necessary to determine the required amount of nitrogen which is the main element. Then, with due regard to local conditions of soil fertility, and specific requirements of the crops in question, the necessary amounts of P_2O_5 and K_2O are determined, so that full utilization of nitrogen fertilizers is assured.

Of interest is the approach to the evaluation of granulated fertilizers. The efficiency of fertilizers depends on the surface of contact (S) of the root system with fertilizers (this surface decreases in area as the diameter of the granules is increased) and on the difference in concentration (C-c) between the point at which the root system makes contact with the granule and the average concentration of the soil. This difference increases as the granule diameter increases. The action of the granules can be expressed in the following formula: $Q = k\,S(S-c)$, i. e. as the granule diameter increases, the decrease in S is compensated by an increase in (C-c). When the diameter of the granules increases to more than 4 or 5 mm, a decrease in their efficiency is observed. Demolon attaches great importance to the use of manure and other organic fertilizers; he notes that during the first year of manure application, 25% of nitrogen, 30% of P_2O_5, and 40% of K_2O are utilized. Ogg considers that 10 metric tons of manure, for all practical purposes, are equal to 20 kg of N, 20 kg of P_2O_5, and 30 kg of K_2O.

In a separate chapter devoted to data of field tests, the possibilities for obtaining yields of various altitudes from the agricultural viewpoint are examined. Shown are variations in yield of different crops, based on meteorological conditions during the year, and ways of forecasting yields on the basis of winter precipitation. Evaluated are factors affecting fertility, such as soil, area of nutrition, fertilizers, type and variety of crop. Demolon also examines the effect of external conditions and agricultural methods on the quality of the various crops. The concluding chapter of the book is devoted to agricultural experiments, particularly to field methods. Along with the presentation of a detailed method for conducting experiments, the method of mathematical processing of the results is discussed in some detail. An addendum of the book consists of a description of methods for the analysis of vegetation.

As can be seen from the brief review of the subjects dealt with in Demolon's book, it contains thorough coverage of all subjects pertaining to the growth and cultivation of vegetation; the book is impressive in the depth of its analysis and the new insight and approach to known agricultural problems.

The book is of great interest to a broad circle of readers. It is of considerable interest to biologists, ecologists, agronomists, crop specialists, agricultural chemists, soil scientists, physiologists, biochemists, meteorologists: in some respects, it may be of interest to mathematicians.

A translation of this book has been prepared for publication by Sel'khozgiz and it is hoped that this work will soon reach publication.

Reviewed by Z. I. Zhurbitskiy

CHRONICLE

EVIEW OF REPORTS PRESENTED AT THE SESSIONS OF THE SOIL FERTILITY SECTION, IRST DELEGATES' CONFERENCE OF SOIL SCIENTISTS. K. V. Verigina

More than 50 reports on questions of soil ertility and agricultural and soil chemistry, ere presented at the sessions of the soil fer- ility section of the soil scientists' conference.

Presented at the first session were reports evoted to the study of stimulation of plant rowth by humic acid (L. A. Khristeva), stimu- ators of growth of petroleum origin (D. M. useynov), and the study of the influence on egetation of humus fertilizers applied in od-podzolic soils (M. M. Kononova and K. V. 'yakonova).

In Khristeva's report the author shows that fficient action on plants results only from a orm of humates that is soluble and then only concentrations of thousands and tens of ousands of a percent. The physiological ction of small amounts of humic acid consists the strengthening of certain oxidation-reduc on processes in plants. Additional yield re- ulting from the use of humic fertilizers con- tituted 30% on sandy and low-humus content oils and up to 10% on highly fertile soils.

Kononova's and D'yakonova's reports con- ained data indicating that under conditions f sod-podzolic soils, humus fertilizers (humo- os) appear to be less efficient than in cherno- ems. The authors explain this by the pres- nce in soils of the podzolic type of significant uantities of available forms of organic sub- tances, among which there are stimulators, hich limit the action of substances that are dditionally introduced into the soil in the umofos compound; in addition, the influence the climatic factor is not to be overlooked.

In experiments conducted by D. M. Gusey- ova it was determined that the introduction to the soil of products of petroleum origin esults in an increase in the productivity of ricultural crops. Among petroleum by- roducts, naphthenic acids influence the fer- lizing action. Introduction of sodium salt naphthenic acids in quantities of 50-300 g/ha improved conditions of plant nutrition, increased the amounts of uptake of phosphorus and nitrogen, and intensified the entry of nutrient elements.

Presentations by Khristeva and Kononova were followed by reports by S. S. Pragunov, V. V. Ozolina, and O. A. Fatchikhina. S. S. Dragunov noted that peat moss and peat-mineral fertilizers show a positive action in soils in Moscow region. Ozolina noted that her experiments (in water cultures) determined the positive action of small amounts of humus substances on plants. Fatchikhina directed attention to the fact that the saturation of turf by ammonium is not sufficiently clear, since under such conditions the positive action of ammonium quickly levels off.

E. N. Mishustin showed in his report that, in soils of various types, certain specific groupings, clearly defining the direction of the soil forming process, are formed by microorganisms. For soils of any climatic zone, specific dominant groups of material, fungi, and actinomycetes are characteristic. The speaker supported his premise with specific examples. Mishustin's report was subjected to criticism by reports of A. V. Rybalkina and M. T. Tyagny-Radno. The latter presented data showing that, under the influence of a number of factors, the visible composition of microflora is strongly varied not only with relation to the type of soil but also in terms of the range of one type of soil. E. F. Berezova noted in her report that the application of mineral and organic fertilizers exerts great and varied influence on the microflora of the soil and the root systems which, in turn, affect the nutrition of plants. When applying fertilizers one must take into account not only the plants' specific fertilizer requirements but also the effect of the fertilizers on the microbiological processes.

N. S. Avdonin presented material with respect to the efficiency of mineral fertilizers in acid sod-podzolic soils. The speaker opposed the view that efficiency of mineral fertilizers is higher, the lower the nutrients in acid sod-podzolic soils. Systematic application of ammonium fertilizers and potassium chloride during the third or fourth year decreases greatly the efficiency of non-limed soil. This is connected with increased acidity, mobile aluminum and manganese content, and the unbalancing of the plant metabolism. On limed soil, systematic application of ammonium and potassium fertilizers progressively increases yield. Phosphorus fertilizers also have a positive effect when systematically applied to acid soils.

The question of the efficiency of fertilizers in virgin soils of the non-chernozem belt was touched upon in the report of A. G. Trutnev. He noted the great variety of virgin soils in the non-chernozem belt (in terms of their potential fertility) and the need for adapting fertilizer application to cultivation.

The effect of fertilizer on increased fertility of podzolic soils under grass-flax crop rotation was discussed by A. D. Kostyuchenko. Many years of experiments and study of the system of fertilizer application to grass-flax crop rotation have shown that constant increase in yields is possible when application of organic and mineral fertilizers is coordinated, when the fields are limed, and fertilizers are applied several times during each rotation.

L. I. Korableva's report touched on the chemical properties and fertility of the flood-plain soils of the non-chernozem belt. The report noted that the principal feature of the soil is their high fertility compared with that of sod-podzolic soils; this was determined by the high saturation of bases, the nearly neutral reaction, and the enrichment by humus, nitrogen, and phosphorus of flood-plain soils. The report further points out that flood-plain soils, as a rule, are poor in potassium.

Fertilizer application in turf-bog soils of the BSSR was discussed in a report by B. B. Bel'skiy. In the BSSR, bog occupies nearly 23% of the territory, of which 80% is bog of the lowland type. Bog-turf soils of the lowland type are potentially highly fertile, but when they are first put under cultivation, phosphorus and potassium must be applied. Of great significance are the times and methods of fertilizer application and the interrelationship between potassium and phosphorus.

Methods of cultivating low productive soils of the Novosibirsk region (Baraba, Kulunda) were examined by I. I. Gantimurov. Bog soils and soils of large columnar solonetz require special methods of cultivation, including the application of manure and mineral fertilizers. An analysis of drainage water indicates a considerable removal of salt; this gives reason to assume that the evolution of turf-bog soils will involve the leaching of these soils.

M. A. Korshunov presented the results of permanent plots of the dynamics of nutrients in ten-fold crop rotation (1 rotation) on grey forest soils (Tatar ASSR), based on a certain system of fertilizer application. His experiment showed that in the course of one grass-crop rotation the nitrogen content and availability of phosphate improved. He noted the positive influence of liming in amounts that corresponded to 0. 5 hydrolytic acidity and the residual effect of liming.

In her report, E. S. Musabekova presented a brief chemical analysis of the principal soils of the Shirvan steppe: chernozems, meadow-sierozems, sierozem meadow, meadow light and dark, sierozem-brown, and chestnut soils. Investigations have shown that the total nutrient content does not necessarily define the degree to which the plants are supplied by it. The best supplied, in terms of nutrients, were the dark-meadow soils. Field experiments have shown that, compared to other soils, they require less application of fertilizer.

Questions of nitrogen nutrition of plants and the nitrate content in the soils were reported on by S. V. Turchin, P. E. Prostakov, and A. I. Simakin.

Turchin, using isotope N15 and methods of chromatographic analysis, obtained interesting data on the entry and processing, by the plants, of various nitrogen compounds.

Turchin also presented new data on the mechanism of nitrogen fixation in leguminous plants; results of tests with N15 indicated that a large amount of tagged nitrogen is found in the cell sap of nodule tissue and is completely absent in bacterial cells. The role of bacteria is to induce the formation of specific nodule fibers. The primary product of the fixation of atmospheric nitrogen in legumes is ammonium.

In his report, P. E. Prostakov postulated that, when efficient methods of soil cultivation are employed, particularly with respect to chernozems, large quantities of nitrate may be accumulated which will assure a nitrate supply that is adequate for the very highest yield. Many methods are available to regulate nitrification in the soil; thus, various methods of soil cultivation with sufficient amounts of moisture, intensify nitrification, the addition of organic-mineral mixtures reduces the movement of nitrates, and the reduction in nitrification capacity is reached by partial sterilization of the soil.

In A. I. Simakin's report results were presented of a study of the dynamics of nitrates and nitrification capacity of Cis-Caucasian soils, leached chernozems of Kuban'. He notes in his report that the nitrate content varies not only with relation to the climatic conditions and agricultural practices but also under the influence of the root activity. While almost no nitrates were observed in plots under cultivation, fallow plots show an accumulation of nitrates in enormous quantities. The study of the nitrification capacity of soils under field conditions gives reason to believe that the disappearance of the basic portion of nitrates in the zone of the root system is not the result of their direct uptake by plants.

A study of soil phosphorus and the application of phosphorus fertilizers were the subject of reports by D. L. Askinazi, N. P. Karpinskiy, V. Zamyatina and A. N. Piskarev.

In his report, D. L. Askimazi examined the various forms in which phosphates appear in sod-podzolic soils, processes that assist in the transition of phosphates in the soil into a soluble state, the significance in the reduction of contact between phosphorus fertilizers and the soil adsorbent and the relationship between soil acidity and efficiency of various forms of phosphate fertilizers. The report discussed conditions of simultaneous application of superphosphate and rock phosphate with calcium carbonate and organic fertilizers.

Reports by M. P. Karbinskiy and V. B. Zamyatina were published in Pochvovedeniye, No. 11, 1958.

In her report, A. M. Piskareva reviewed the role of phosphorus, applied in fertilizers in plant nutrition. Experiments with radioactive phosphorus showed that the entry of phosphorus into plants may be followed either by an increase or a reduction in the utilization of soil phosphates, depending upon the properties of the soil. Utilization of phosphorus from fertilizers depends on the time at which they are applied. Phosphates, applied prior to planting, increase the yield considerably; when applied under crop, they have little influence on the yield increase.

Only one report, that by I. G. Vazhenin, was devoted to action of potassium on the soil. The report, soon to be published in Pochvovedeniye, examined various forms of potassium in the soil and their availability to plants.

Reports on the subject of soil acidity were presented by V. A. Chernov and V. S. Maksimova, S. N. Aleshin, I. P. Serdobol'skiy, and De Glerie (Hungary). The latter report will be published in its entirety in Pochvovedeniye No. 10, 1958; for that reason we shall not discuss it in detail here.

The article by Chernov and Maksimova examines the change, over a period of time, of adsorbed cations in the soil that are saturated with hydrogen ions. In clay, saturated with hydrogen ions, over various periods of time, there takes place a spontaneous reaction involving the displacement of hydrogen ions by aluminum ions, as well as by calcium and magnesium ions. The authors presented an equation to which this displacement reaction is subject.

S. M. Aleshin presented his views on a process, in soils, of a non-exchangeable adsorbed hydrogen which is governed by the ability of oxygen ions of aluminum silicate tetrahedrons and octahetrons to form hydroxyl ions which can cause qualitative and quantitative changes in minerals constructed on the basis of these and analogous structural units. The report discusses experimental data obtained on the basis of x-ray, electronic-microscopic, thermographic, and other investigation methods which proved, in the opinion of the author, the non-exchangeable adsorbed hydrogen ions on soil. The report stresses the significance of the non-exchangeable adsorbed hydrogen and as a principal factor in the evolution of soils.

I. P. Serdobol'skiy postulated the chemical exchange theory. Based on this theory, exchange takes place in a heterogenous environment not at the surface of the soil particles, but in solution, after the cation of the solid phase of the soil has entered it, and as a result of the dissolution of hydrolysis. Solution is accompanied by precipitation with cations of the displacer going into the precipitation when there is an excess of the displacer. Repeating itself constantly, this process results in the accumulation, in the liquid phase, of cations of the solid phase of the soil, with the displacer cations accumulating in the solid phase; as a result the exchange reaction takes place.

A discussion was held in a special session of the Chemistry and Soil Fertility Section on the question of the nature of soil acidity.

A report by O. G. Khallik dealt with the influence of liming on the fertility of acid soils of Estonia. In Estonian SSR, 40% of the plowland is acid soil, of which 27% is strongly acid. Field tests extending over many years, with various amounts of lime, indicated that the optimum amount of lime is that based on 0. 5 magnitudes of hydrolytical soil acidity. The residual effect of the liming was observed during experiments extending over a period of ten years. Liming reduced the mobile aluminum content, increased the quantity of nitrates and available phosphates, and also had a positive effect on the physical properties of fine-textured soils, particularly with perennial grasses.

A communication by A. Ya. Zirnitis was devoted to the question of efficiency of liming in gray forest soils of Tomsk region. The influence of liming with slaked lime and local lime fertilizers on red clover, winter rye, and spring wheat was studied. The crop that responded most to liming was clover, particularly when planted in soils that had been cultivated little. With 20 metric tons/ha of manure, the efficiency of liming appeared to be considerably lower. The lowest response to liming was registered by spring wheat; winter rye showed marked increases in yield with only small amounts of non-slaked lime (5-6 cntr/ha) added; when the amount was doubled, the effect of the lime decreased.

O. K. Kedrov-Zikhman, in his report, touched on the question of the influence of calcium as a nutrient for plants in limed acid sod-podzolic soil. On the basis of results of pot experiments conducted with various plants and with the application of Ca^{45}, the author arrived at the following provisional conclusions: 1. The Ca content in the soil which is available to the plant depends on soil properties and particularly on adsorption capacity. For limed soils the available calcium content depends also on the amount of lime and the content of magnesium used in the fertilizer. 2. The entry of calcium into the plant to a significant degree depends on the biological peculiarities of the plant. 3. Various organs of the plant contain differing quantities of calcium: the leaves contain the largest amount of it, while the seeds contain the smallest portion. Calcium content in leaves varies, depending upon its content in the nutritive environment; calcium content in seeds is stable. 4. Radiation of Ca^{45} under certain conditions may show a positive as well as negative influence on the growth, development, and yield of the plants.

The following scientists devoted their reports to the study of micro-element content in the soil, the application of micro-element fertilizers, and methods for the determination of micro-elements in the soil that are available to plants: Ya. V. Peive, M. V. Katalymov, P. A. Vlasyuk, G. Ya. Rinkis, and R. Kh. Aydinyan.

Reports presented by Peive and Katalymov examined the question of the influence of soil conditions on the application efficiency of the following micro-element fertilizers: boron, copper, zinc, manganese, cobalt, and molybdenum. As was shown by Peive, the highest efficiency of boron fertilizers is observed in soils that are poor in boron, such as sod-clay and dark-colored soils of the podzolic zone, as well as in acid, sod-podzolic soils, after liming. In gray forest soils and chernozems, the efficiency of boron fertilizers is reduced. Soils of the southern regions of the USSR — chestnut, solonetz, and solonchaks, are rich in boron and do not need additional amounts of it.

The experiments determined that application of copper fertilizers in turf-soils that contain little copper and in copper-poor sandy soils is most efficient. The availability of copper in soils increases when they are acidified, when organic substances are mineralized, and when ammonification and nitrification are developed. Fixation of copper through liming and through addition of organic compounds brings about a reduction in the availability of copper to the plant.

It was determined with respect to zinc that the quantity of zinc available to plants is reduced when the soils are made alkaline and is increased when it is acidified. In soils of the sod-podzolic zones zinc fertilizers appeared to be more effective than on sod-carbonate soils.

Mobility of manganese in soils is also tied in with soil acidity; however, an important role in the transition of the manganese into a mobile state is played by the oxidation-reduction conditions of the environment. Liming of soils reduces manganese mobility and increases the need for manganese fertilizers. Manganese fertilizers have been successfully applied in weakly leached chernozems, gray-forests, chestnut, and solonetz soils.

It was noted that the soils in the northern non-chernozem belt in many cases are poor in Co. The acid reaction of the soils facilitates the transition of Co into an available state and liming fixes it. The application of cobalt fertilizers must be used on the basis of consideration of the content of available cobalt in various soils.

Utilization of soil molybdenum increases with liming of acid soils and with the application of phosphates, particularly efficient in strongly podzolic soils.

Katalymov's report also touched upon the efficiency of micro-element fertilizers with relation to soil conditions. The report stressed that the action of lime on the decrease in the availability of B, Fe, and Co is tied to the change in reactions and is to a much lesser degree dependent upon the increase in calcium concentrations. Katalymov's report further notes the insufficient content of iodine in soils of the northern non-chernozem belt and on the need for applying iodine fertilizers.

P. K. Vlasyuk presented data on the content in soils of the Ukrainian and Moldavian SSR's of available and other forms of manganese, zinc, boron, cobalt, and copper. As a result of investigations over a period of years he determined the reserves of available forms and prepared cartograms of the content of these micro-elements in various soils of the Ukrainian and Moldavian SSR's. Based on investigations carried out in the Ukrainian SSR, manganese and copper fertilizers are widely used in connection with various agricultural crops.

Up to the present time an important shortcoming in the matter of micro-element fertilizer application was the lack of simple methods for the determination of content in the various soil forms of micro-elements that were available to the plant; for this reason the proposals presented by Ya. B. Peive and G. Ya. Rinkis, entitled "Field Laboratory for the Determination of Micro-elements in Soils Available to Plants (B, Cu, Zn, Mn, Co, and Mo)," is of great practical significance. The authors presented their report and demonstrated a device they had built. To determinemicro-element content available to plants it is recommended that they be extracted from the soil with various solvents by colorimetric determination and comparison with special colored film scales.

P. Kh. Aydinyan's communication dealt with the distribution of rare alkalis (Rb, Cs, and Li) in soils, colloidal and pre-colloidal fractions of these soils, and plants growing on these soils. It was determined that, in various soil types, the greatest accumulation of rare alkalis takes place in colloidal and, to a lesser degree, in pre-colloidal fractions. A significant portion of rare alkali elements is found in available form. In plants (such as the tea plant) rubidium, as well as potassium, are accumulated in vegetative and reproductive organs. Cesium and rubidium are accumulated in large quantities in young leaves.

A. V. Peterburgskiy reported on the role of adsorption processes in the soil and their influence on the root nourishment of plants. His experiments indicated that plant nourishment can be accomplished with the aid of adsorbed ions. The mechanism of extraction, by the plants, of ions from the adsorbent and their subsequent absorption by the root system takes place, in our opinion, during the interaction between ions of the root hairs and soil particles, through the film of the solution.

I. I. Kanivets, in his report, dwelled on the correct application of a number of measures to increase fertility of orchards. He discussed the fact that particular attention should be paid to soil cultivation, adapting cultivation methods to the depth of existing root systems, and alternating the cultivation of fallow with legume crops. When applying fertilizers, one must take into account the variety of nutrients present in the orchard soils having many different species of fruit trees.

A communication by L. A. Frolkina dealt with the restoration of chernozem fertility of the Kamen steppe. Here, there is a wide area of micro-depressions, which frequently loses crops, particularly in winter, and also meliorative methods used on solonetz soils. Experiments were carried out to determine the effect of removing upper layers of the chernozem on productivity of agricultural crops. They showed that in ordinary chernozem the removal of the upper layer to the extent of 10-15 cm does not affect the amount of yield. When the upper layer is removed to a depth of 25 cm, application of mineral fertilizers is necessary. Further increase in the depth of the removed horizon is not expedient.

In his report, I. E. Bukhar discussed experiments to determine the influence of deep moldboard plowing and of plowing without moldboard on the field crop yield in thick, ordinary clay-loam chernozem in Moldavian SSR. Experiments indicated that moldboard plowing is more advantageous than ordinary plowing. Deep moldboard plowing increases soil moisture, which is a limiting factor, and increases plant nutrients in soil. It affects the effeciency of fertilizer thereby affecting the yield, depending on the particular agricultural crops. Plowing without moldboard is not only ineffective under conditions prevailing in Moldavian SSR, but also increases weediness to a considerable extent in the fields and in that connection causes a decrease in yield.

The Polish scientist I. I. Tomaskevski presented two reports at the meetings of the Soil Fertility Section. He touched upon the processes of decomposition and transformation of organic substances in the soil. According to him, organic substances in the soil may be subject to the following basic processes: 1. Mineralization, humus formation, turf-formation, mursh-formation and carbonization. Mineralization is the process of complete decomposition of organic substances. Humus formation is a process leading to the formation of organo-mineral complexes that have colloidal properties and are stable with respect to decomposition. Turf formation is a complex process that takes place under conditions of excess moisture and absolute anaerobiosis, leading to the accumulation of a turf mass, primarily at the expense of more stable organic substances that resist decomposition. Mursh formation is a complex process that causes decomposition and the formation of organic substances in periodically variable conditions of moisture and aeration. Under the influence of this process, turf is transformed into a biologically inert, hard mass, black in color, called mursh. Carbonization means the coal formation of organic substances under conditions of absolute anaerobiosis.

Tomashevski's second communication touched on the dynamics of soil fertility. Soil fertility depends on a number of factors: ecological conditions, a complex of organic and organo-mineral compounds, a complex of mineral compounds, and soil structure. Increased fertility of the soil must be based on measures that are directed toward the change of all the foregoing factors.

The review of the reports did not cover papers that were published in Pochvovedeniye.

OBITUARY

ALEKSANDER ALEKSANDROVICH ZAVALISHIN (IN MEMORIAM)

Editorial Board of Pochvovedeniye, V. V. Dokuchayev Soil Institute and Central Soil Science Museum, Academy of Sciences, USSR

Professor Aleksander Aleksandrovich Zavalishin, one of the outstanding soil scientists of the USSR, died on December 23, 1958, in Leningrad after a serious and protracted illness.

A. A. Zavalishin was born on August 19, 1902, in Leningrad. In 1920 he entered the Petrograd Agronomic Institute (known, after 1924, as the Leningrad Agricultural Institute). In 1921 and 1922 he attended a soil science course given by A. A. Gedroits, whose interesting lectures first stimulated Aleksander Aleksandrovich's interest in soil science. Even as a student he worked in the Soil Science Department of the Leningrad Agricultural Institute, headed at that time, by professor K. D. Glinka.

In 1924, after graduating from the Leningrad Agricultural Institute (LSKhI), A. A. Zavalishin was appointed to the Soil Science section of the Institute's experiment station. In 1925 he was assigned to the Pashe-Kapetsk scientific-experiment forest station of the Leningrad Agricultural Institute (in Tikhvinsk region of Leningrad Oblast') to study the soils of the area. From 1926 to 1928 Zavalishin was an instructor in the Soil Science division of the Leningrad Agricultural Institute, headed by academician K. D. Glinka.

Between 1927 and 1930, he worked as a member of the Transcaucasian expedition of the Commission for Expedition Research of the Academy of Sciences, USSR, as chief of party in charge of soil studies in the vicinity of Lake Sevan.

In the fall of 1928 he was assigned as a member of the V. V. Dokuchayev Soil Institute of the Academy of Sciences, USSR, where he worked until 1945. In 1935 he was promoted to Senior Science Associate of the Institute.

In 1931 Zavalishin was assigned as a member of the Kuznetsk-Barnaul expedition of the Dokuchayev Soil Institute of the Academy of Sciences, USSR, headed by L. I. Prasolov. In the course of the work, involving a study of the soils of the Kuzbass, he compiled a soil map of the latter and headed the work involving the study of the urban zones of the principal industrial centers of the Kuzbass. Between 1933 and 1936, as a member of the Volzhsko-Kamsk expedition of the Academy of Sciences, USSR, he headed the work on soil surveys of the Mologo-Sheksninsk River delta, conducted by A. A. Afanas'eva, O. A. Grabovska, and D. G. Mikheyev. He personally conducted soil surveys of the valleys of the upper Volga, the Unzha and Kostroma, as well as repeated surveys of the Volkhov river.

In the fall of 1935, by decree of the presidium of the Academy of Sciences, USSR, Zavalishin, without presentation of a thesis was awarded the title of a Candidate in Soil Sciences, in recognition of his outstanding work in geography and soil genesis. On January 25, 1938, at a session of the Scientific Soviet of the Soil Institute of the Academy of Sciences, USSR, Zavalishin defended his doctor's thesis in agricultural sciences on the subject of "The Soils of the Kuznetsk Forest Steppe." In the spring of 1940 he was appointed professor.

In 1936 and 1937 Zavalishin conducted soil research of the Lenkoransk region of Azerbaydzhan SSR, as a member of the Talysh expedition of the Soil Institute; in 1937 he was appointed head of that expedition, and in 1938 worked in the BSSR on a review of soil maps of the republic. In 1939 he began semi-permanent investigations in Moscow Oblast' on the study of the dynamics of soil processes in bog and dry-land areas.

In 1940, Zavalishin was appointed Manager of the Soil Institute of the Academy of Sciences, USSR, and pursued the study of the soils in Moscow Oblast'. The work was interrupted by the great Patriotic War. Upon evacuation to the city of Kazan', in 1942 and 1943, he participated in the work of the Urals expedition of the Academy of Sciences, USSR, and studied the soils of the northern Trans-Urals; in 1944 he headed the study of soils of the Serebryano-Prudsk region of the Moscow Oblast'. In the fall of 1945 Zavalishin was transferred to the Soil Science Museum in Leningrad which in 1946 was redesignated the Central Soil Science Museum, named after V. V. Dokuchayev. Zavalishin remained a Senior Science Associate of the museum until the last days of his life, taking an active part in the general reconstruction of the museum (1950 to 1958). From 1949 to 1952 Zavalishin headed the soil section of the combined Kaliningrad expedition of the Academy of Sciences, USSR.

Upon moving to Leningrad he began to work in the Leningrad State University as a professor in soil geography. In 1948 he succeeded E. B. Polynov as head of the department, remaining in this position until his death.

Zavalishin repeatedly carried out a number of responsible scientific-organizational assignments. Between 1930 and 1932 he was twice appointed Science Secretary of the Soil Institute, and, in 1930, was elected Science Secretary of the Leningrad Organizational committee for the Second International Soil Science Congress; between 1941 and 1945 he acted as Senior Secretary of the Editorial Board of the Journal Pochvovedeniye and, from 1946 until his death, was a member of the Editorial Board. In 1940 he was the Science Secretary of the Interadministration Commission for Soil Classification.

Zavalishin completed 48 works, a portion of which is still in preparation for publication. Some of these papers were written by him jointly with other investigators. The most important of these works are his papers on geography and the genesis of soils of the podzolic group. Some of the papers represent original research in soils of one or another territory. Such works were devoted to the soils of the following areas: Pashe-Kapetsk, Trans-Urals, Moscow Oblast', Tul'sk National Forest, Kaliningrad Oblast', etc. He began to write and to publish early in his career; among such early works are maps of soil regions in Leningrad Oblast' and Karelia, prepared jointly with N. N. Rozov and O. A. Grabovska, and published in 1934. Another (jointly with A. A. Khantulev) was a paper on the soil regionalization of the north and northwest portions of the USSR (currently in print). Still another was a work on "Characteristics of the Principal Subgroups on Soil in the Forest Zone of the European portion of the USSR," published in 1954; in this work, he was first to present a fundamental analysis of the subclassifications of podzolic soils into subgroups. This work is also of great methodological value since it shows how analytical materials are to be used in the solution of classification problems.

Six works, published between 1928 and 1937, present results of research in soils of the Sevan Lake region. Three works contain a collection of unique material on the soils of the Kuznets forest steppe. In the final work of the series "On the Interrelationship between Quantities of Extraction and Accumulation of Podzolic Soils in the Forest Steppe" (1936) the author brilliantly reviews questions of genesis of forest-steppe soils, based on a thorough analysis of factual material consisting, primarily, of analytical data on the composition of these soils and their properties.

Certain other works are devoted to subtropical soils of Talysh. Unfortunately, a portion of this work remained unpublished.

Among works devoted to general questions of soil classification, the most important is one produced jointly with I. P. Gerasimova and E. N. Ivanova, entitled "A New Scheme for General Classification of Soils," published in 1939. In this work Zavalishin's contribution is a discussion of the classification of taiga and forest-steppe zone soils.

Two works of Zavalishin's relate to the question of gleying. One of these was written immediately after he graduated from the Leningrad Agricultural Institute, while the second, produced jointly with K. V. Verigina and G. P. Maksimyuk, was published in 1940.

During the last years of his life, Zavalishin dealt with certain general questions in soil science. He published an article entitled "The Teachings of Dokuchayev on Factors of Soil Formation, as a Basis of a Comparative-Geographic Method for the Study of Soils" (1958) and prepared for publication a work entitled "On the Question of Basic Principles of Methodology of Soil-Geographic Research," in which he touches on a number of basic problems. He is also the author of several popular works and of four scientific-biographical sketches.

As can be seen from the foregoing, the scientific heritage of Zavalishin is great. A characteristic of most of his works, particularly of those published in the last 10 or 15 years, is that he not only solves problems that constitute the main subject matter of a given article, but he always presents and resolves general questions of soil genesis and indicates new avenues, new methods for the solution of these questions. This is the great value of his scientific work which will long serve as a guide to soil scientists. Zavalishin was not only an important researcher, but also a talented teacher. Wherever he worked, in the laboratory, or in the field, he had the ability to inspire his coworkers and students.

His death means the departure of a deeply thinking scientist who had much to contribute greatly to the development of soil science and to the utilization of that science in the great works in the development of the national economy. He died at the peak of his creative strength when, utilizing his wealth of experience, he had started work on the publication of a large amount of scientific material collected over a period of 35 years.

The death of A. A. Zavalishin constitutes a great loss to science.

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